THE UNIVERSITY OF QUEENSLAND

AUSTRALIA

The family food environment and its relationship with eating behaviours in early childhood (2.0 – 5.0 years) and the implications for obesity development.

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A thesis submitted for the degree of Doctor of Philosophy at

The University of Queensland in (2018)

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Abstract

Introduction: Childhood obesity is an issue of great public health concern. [1] The early childhood period (2.0 – 5.0 years) provides a unique and critical window in which to address the emergence of obesity, as it is during this time that children become active participants in the socio-cultural exchanges that contribute to obesity development. [2] According to the behavioural susceptibility theory, obesity emerges when genetic susceptibility and environmental circumstances interact and obesogenic behaviours ensue. [2] Consequently, interventions in early childhood that target behaviour change through environmental modification, offer promise in prevention of childhood obesity. In this regard, the family food environment (FFE), as the 'first ecological niche of children,' encompasses a range of potentially modifiable environmental factors. [3-7] Conceptualised to comprise the interpersonal and micro-environment influences within the home, the FFE may consequently provide an avenue from which to affect change in 'obesogenic' behaviours, such as children's eating behaviours. [3-7] It has been estimated that environmental factors, such as those within the FFE, account for approximately 45% of variance in children's eating behaviours and 28% of variance in child BMI. [3, 4]

Current understanding of the array of FFE variables that, individually or collectively, interact with children's eating behaviours to contribute to obesity status in early childhood appears fragmented and fails to draw a comprehensive picture of environmental exposures. Furthermore, understanding of differences in children's eating behaviours based on psycho-social variables is limited. A greater understanding of these contributors to eating behaviours could lead to the development of novel strategies for behaviour change and obesity prevention. This thesis aimed to draw a comprehensive picture of the FFE of Australian children during early childhood and develop an understanding of the influence this environment has on children's eating behaviours and obesity status. This thesis further aimed to determine parent's acceptability towards intervention opportunities, particularly those delivered online and those designed to address identified child feeding issues within the FFE, as a means of altering children's eating behaviours and reducing obesity risk.

Method: Two cross-sectional studies were conducted. The first study consisted of an online survey (survey 1) of 1186 parents of Australian children (2.0 – 5.0 years of age) recruited via Facebook®. Data on variables conceptualised within the FFE were collected, along with data on children's eating behaviours, self-reported parent and child BMI, and

psycho-social variables. The second survey (survey 2) recruited a new sample of 310 parents of Australian children (2.0 – 5.0 years of age) via Facebook®. Items in this survey were designed to assess parent's acceptability towards child feeding intervention opportunities, particularly those delivered online, with items aligning with the constructs of the health belief model (HBM) and social cognitive theory (SCT). All data analysis were performed quantitatively using SPSS (SPSS Inc., Chicago, IL, USA).

Results: Data analysis from survey 1 (n=977) demonstrated that food responsiveness and satiety responsiveness were associated with child body mass index z-score (BMIz), controlling for psycho-social variables (B=0.188, p=0.020 and B=-0.260, p=0.013, respectively). A range of FFE variables (e.g. parent's feeding practices, parent's shopping skills, having sufficient money to buy food each week, parent's nutrition related beliefs), were seen to interact with these eating behaviours, however, only parent's use of overt restriction was positively associated with child BMIz (B=0.132, p=0.048). This relationship was mediated by food responsiveness (accounting for 5.75% of the effect, controlling for demographic variables). As a more authentic reflection of the FFE exposure experienced by children, factor analysis showed four factors of FFE variables to be related to child BMI category (n=758); scores for 'Negative feeding strategies' (p=0.046) and 'Negative nutrition-related beliefs' (p=0.004) increased with child BMI category, while scores for 'Use of TV and devices' (p=0.049) and 'Parent's nutrition knowledge' (p=0.032) decreased with child BMI category. 'Negative feeding strategies' and 'Negative nutrition-related beliefs' were both also positively associated with food responsiveness (B=0.305, p=0.000 and B=0.117, p=0.018, respectively). Results from survey 2 indicated that parents may be more inclined to engage with child feeding interventions that frame core messages around fussy eating behaviours, as opposed to obesity directly. Barriers within FFEs, particularly lack of time and money, and child tantrums, should be addressed in such future child feeding intervention, that are preferably delivered online (although face-to-face interventions still hold appeal, particularly for lower educated parents).

Conclusion and implications for practice: The findings of this thesis provide support for early childhood obesity prevention interventions to focus on the intermediary role of children's eating behaviours, particularly food responsiveness, by targeting variables within the FFE. Interventions should aim to engage parents by framing content towards fussy eating as a key issue of concern, while addressing relevant barriers in creating a healthful FFE. Internet based platforms appear promising for use in future intervention delivery.

Declaration by author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

I have clearly stated the contribution of others to my thesis as a whole, including statistical assistance, survey design, data analysis, significant technical procedures, professional editorial advice, financial support and any other original research work used or reported in my thesis. The content of my thesis is the result of work I have carried out since the commencement of my higher degree by research candidature and does not include a substantial part of work that has been submitted to qualify for the award of any other degree or diploma in any university or other tertiary institution. I have clearly stated which parts of my thesis, if any, have been submitted to qualify for another award.

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Publications included in this thesis

- Boswell, N., Byrne, R., Davies, PSW. (2018). Aetiology of eating behaviours: a possible mechanism to understand obesity development in early childhood. Neuroscience & Biobehavioral Reviews. doi: 10.1016/j.neubiorev.2018.10.020. **Available from:** https://www.sciencedirect.com/science/article/pii/S0149763418304457?via%3Dihub

- Boswell, N., Byrne, R., Davies, PSW. (2018). Eating behaviour traits associated with demographic variables and implications for obesity outcomes in early childhood. *Appetite, 120*, 482-490. doi: 10.1016/j.appet.2017.10.012. **Available from:** http://www.sciencedirect.com/science/article/pii/S0195666317308929

- Boswell, N., Byrne, R., Davies, PSW. (2018). An examination of children's eating behaviours as mediators of parents' feeding strategies on early childhood obesity. Obesity Science and Practice. doi:10.1002/osp4.320. **Available from:** https://onlinelibrary.wiley.com/doi/full/10.1002/osp4.320

- Boswell, N., Byrne, R., Davies, PSW. (2019). Family food environment factors associated with obesity outcomes in early childhood. BMC Obesity. doi: 10.1186/s40608-019-0241-9. **Available from:** https://bmcobes.biomedcentral.com/articles/10.1186/s40608-019-0241-9

- Boswell, N., Byrne, R., Davies, PSW. (2018). Prospects for early childhood feeding interventions: An exploration of parent's concerns and acceptability towards social media intervention opportunities. Nutrition and Dietetics. doi: 10.1111/1747-0080.12502: **Available from:** https://onlinelibrary.wiley.com/doi/abs/10.1111/1747-0080.12502

Submitted manuscripts included in this thesis

No manuscripts submitted for publication

Other publications during candidature

No other publications

Contributions by others to the thesis

Peter Davies and Rebecca Byrne supervised the development and preparation of this thesis, including assistance in content editing. Dr. Anne Bernard of QFAB Bioinformatics (University of Queensland) provided general statistical analysis support.

Financial contributions were received for this thesis in the form of a University of Queensland Research Scholarship (living allowance stipend). Funds were also received from the Children's Nutrition Research Centre (University of Queensland) to support recruitment, conference attendance and related incidental costs.

Statement of parts of the thesis submitted to qualify for the award of another degree

No works submitted towards another degree have been included in this thesis

Research Involving Human or Animal Subjects

Ethical approval for this research project was granted through the Behavioral and Social Sciences Ethical Review Committee, The University of Queensland (approval number 2016000860 and 2017001504).

Acknowledgements

This thesis has been made possible through the support, patience and encouragement of many people.

Firstly, my supervisory team, Peter Davies and Rebecca Byrne, thank you for sharing your wisdom and wealth of experience. While working remotely has had its challenges, you have both been dedicated and supportive throughout this journey. Through your expertise and guidance, I have gained skills in research, whilst also developing confidence in my academic ability. These skills and confidence will be invaluable as I move forward in my career.

I would also like to thank the fellow PhD students that I had the opportunity to meet – your experiences provided me with inspiration and motivation. In particular, Dr Ruth Newby, your kindness, support and friendship has been monumental.

I wish to acknowledge Dr. Anne Bernard who provided statistical support, UQ for financial support, and, thank the parents who gave their time to provide the data that made this thesis possible.

Finally, I would like to thank my family who has sacrificed so much to support me. My husband, Ben, who has encouraged me, shared the emotional toll, and acted as my IT support; my three children, who have been as understanding as possible; and of course, my parents and in-laws who have picked up the slack and helped me to retain my sanity while continuing towards my goal. Thank you for helping to make this thesis possible.

"It always seems impossible until it is done" (Nelson Mandela)

Financial support

This research was supported by a University of Queensland Research Scholarship (UQRS).

Keywords

Childhood obesity, early childhood, eating behaviours, family food environments, psycho-social variables, parent feeding strategies, parent feeding practices, behavioural susceptibility theory, online interventions, intervention acceptability study,

Australian and New Zealand Standard Research Classifications (ANZSRC)

ANZSRC code: 111712, Health Promotion, 40%

ANZSRC code: 111704, Community Child Health, 30%

ANZSRC code: 111104, Public Nutrition Intervention, 30%

Fields of Research (FoR) Classification

FoR code: 1117, Public Health and Health Services, 50%

FoR code: 1111, Nutrition and Dietetics, 50%

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List of Figures and Tables

List of abbreviations used in the thesis

BMI – Body Mass Index

BMIz – Body Mass Index Z-score

CBT – Cognitive Behavioural Therapy

CCK - Cholecystokinin

CEBQ – Children's Eating Behaviour Questionnaire

CFPQ - Comprehensive Feeding Practices Questionnaire

CFQ - Child Feeding Questionnaire

DASS – Depression, Anxiety and Stress Scale

DOR – Division of Responsibility

FFE – Family Food Environment

FPSQ -Feeding Practice and Structure Questionnaire

FTO – Fat Mass and Obesity-Associated gene

HBM – Health Belief Model

HPA-axis - Hypothalamic Pituitary Adrenal axis

INFANT - Infant Feeding Activity and Nutrition Trial

MC4R - Melanocortin-4 receptor

PATFA - Parent and Toddler Feeding Assessment

PEACHES - Physical Exercise and Appetite in Children Study

SCT – Social Cognitive Theory

SES – Socio-economic status

WHO - World Health Organisations

Glossary of Key Terms	
Appetite	Refers to neuro-biological (objective) measures of ‘wanting’ to eat, encompassing both physiological needs (hunger) and psycho-social desires (emotional and social eating).
Body Mass Index (BMI)	A scale measure based on body mass (in kilograms [Kg]) divided by the square of body height (in metres [m]). Expressed in Kg/m^2, this index is used as an indicator of population health risk and cut offs applied to define ‘underweight,’ ‘normal weight,’ ‘overweight’ and ‘obese’ classifications.
BMI z-score/ BMIz	Standard deviation BMI scores
Deviations in eating behaviours	Eating behaviours that diverge from maintenance of energy homeostasis.
Division of responsibility (DOR)[8]	Responsive feeding concept developed by Satter (1990) whereby parents are described as being responsible for *what*, *when* and *where* a child eats, while the child is responsible for *how much* and *whether* they eat.
Early childhood / Young children	Children aged 2.0 years to 5.0 years.
Eating behaviours	A broad range of observable and/or subjectively measured behaviours related to food intake, choice, motives, and eating-related practices.
Family food environment (FFE)	Encompassing variables within the home environment including interpersonal factors (e.g. parent-child interactions) and micro-environment factors (e.g. physical elements and resources within the home).
Food approach eating behaviours	Describing behaviours that involve a movement towards or a desire for food.
Food avoidance eating behaviours	Describing behaviours that involve movement away from food.
Food utilization skills	Personal skills that dictate household level decision related to food purchasing, preparation and allocation/distribution (e.g. cooking skills, food purchase, budgeting).
Hedonic appetite	Drivers of food intake that provide further motivation to eat in order to fulfil needs for neurological stimuli (such as psycho-social feelings of pleasure, comfort or gratification).
Homeostatic appetite	Drivers of food intake that serve the essential physiological function to motivate eating in order to satisfy energy needs.
Obesogenic eating behaviours	A profile of eating behaviours associated with obesity (e.g. high food responsiveness scores and/or low satiety responsiveness scores).
Older children	Children beyond 5.0 years of age.
Responsive feeding strategies	Practices that support children’s self-regulation of food intake including establishing routines and structure around eating and facilitating children’s autonomy and self-regulation of food and energy intake; reciprocity between child and caregiver.

1.1 Childhood obesity: an issue of public health concern

Rates of overweight and obesity have continued to rise over the past three decades. [9] National data currently show that at 4 – 5 years of age 15.2% of Australian children are overweight and 5.5% are obese. [10] Prevalence increases with age during childhood, with results from the 2014 – 2015 Australian Health Survey showing that over one quarter (27.4%) of children aged 5 - 17 years were overweight or obese. [10, 11] Being obese during childhood significantly increases the risk of being obese as an adult and increases the risk of cardiovascular disease, Type 2 diabetes, some musculoskeletal conditions and some cancers. [12-14] Children with obesity experience stigmatisation which can impact psycho-social wellbeing, as well as increase the risk of asthma, susceptibility to heat intolerance, tiredness, foot pronation, and gastrointestinal and neurological morbidities. [15-17] Further to this, rates of overweight and obesity in Australian children aged 2 - 4 years have a direct annual cost to the healthcare system estimated to be $17 million, 1.62 times higher than that of healthy weight children. [1, 18]

Rates of obesity, however, are not distributed equally within the population, with rates higher among families of low socio-economic status (SES), children of single parents, and residents of rural/regional areas. [10, 19, 20] This inequitable prevalence of obesity highlights environmental and social underpinnings which surpass individual responsibility and require dedicated public health attention. [9, 21] In this regard, obesity is a complex and multifaceted condition that, despite many years of attention in the literature and public health sector, is not yet completely understood and consequently remains an issue of priority. At its most simplistic level, obesity, as defined as abnormal or excessive body fat accumulation, is due to an imbalance of energy intake and energy expenditure causing disequilibrium in energy homeostasis. [22] However, to understand obesity beyond this simple equation requires exploration of drivers of excess energy intake at both an individual and a population level. While inhibitors of energy expenditure are also likely to make a significant contribution to obesity development, those contributing factors (e.g. lack of physical activity) are outside the scope of this thesis.

In attempting to understand development of obesity, much attention has been given to the role of dietary intake and dietary patterns as a foundation element in energy disequilibrium. [22] In developed countries there is an abundance of highly palatable, ultra-processed, energy dense foods that are readily accessible and heavily marketed within all sectors of the community. Consequently, national data indicate that there is an excessive intake of ultra-processed 'discretionary' foods and inadequate intake of nutrient-dense 'core' foods such as fruits and vegetables. [11] While dietary patterns are considered a key component in the development of obesity in adults, the associations are less consistent in children. [23] A brief review of the literature identified 13 studies examining dietary pattern and obesity status, with participants from various nationalities ranging in age from 14 months – 39 years. [24-32] Although many of these studies reported positive associations with diet of increasing quality, or positive alignment with dietary recommendations, and reduced rates of obesity (as measured by body mass index [BMI] or adiposity), overall findings were inconsistent. [24-32] A systematic review of high-quality prospective studies further supports the inconsistencies noted, with only 4 out of 7 included studies showing positive associations between dietary pattern and child BMI/adiposity. [24-33] Further details of the literature reviewed in relation to dietary patterns and childhood obesity can be seen in Appendix 1.

Given the inconsistencies between dietary patterns and obesity status in children, the role of eating behaviours have gained attention as being of further importance in understanding the energy disequilibrium that underpins obesity. [22] Eating behaviours are described to encompass a broad range of behaviours related to food intake, choice, motives, and eating-related practices. [34] In this regard, eating behaviours are considered a manifestation of complex physiological, biological, psychological and sociological eating-based determinants. From this perspective, there is a wide body of literature (as discussed in chapter 2), indicating that food approach eating behaviours (as subjective measures reflecting observed behaviours that involve a movement towards or a desire for food e.g. food responsiveness, enjoyment of food, desire to drink, emotional over eating) are positively associated with increased weight status in children, while food avoidance eating behaviours (as subjective measures reflecting observed behaviours that involve movement away from food e.g. satiety responsiveness, food fussiness, slowness in eating, emotional under eating) are associated with decreased weight status in children. [5, 7, 35, 36] Consequently, gaining understanding of how food approach and food avoidance eating behaviours emerge, develop, and differ based on environmental circumstances during childhood, provides opportunity to target obesity prevention initiatives.

In this regard, eating behaviours are considered to be driven by internal neuro-biological regulatory systems as well as by external factors such as those within the food environment, as consistent with the behavioural susceptibility theory (section 1.2.3). [37, 38] Specifically, environmental factors have been estimated to account for approximately 45% of variance in children's eating behaviours, 28% of variance in child BMI, and between 9% - 21% of variance in child diet quality. [3, 4] For children during early childhood, these external factors are concentrated within the family food environment (FFE), as the 'first ecological niche,' of children. [39] It is within this context that individuals experience daily life, develop expectations with respect to values, behaviours and interactions, and that perceptions and cognitions related to health are shared and evaluated. [40] These factors interact with innate and genetic predispositions, typical periods of growth, and typical childhood development, to ultimately influence a child's obesity risk. [12, 13, 41-44] Parents act as primary gatekeepers of the FFE through decision-making, control and management of resources, transposing of values, and structuring of routine and socio-cultural interactions. Parents also act as gatekeepers of upstream influences, such as food advertising and marketing, political structures and agricultural policy (section 2.3). Thus, understanding the FFE as an external driver of eating behaviours and as the key context in which internal drivers of eating behaviours interact, is likely to be pivotal in understanding childhood obesity and consequently in planning obesity prevention initiatives. [39, 44]

1.2 Overall aim and approach

Given the high importance of childhood obesity as a public health issue, this thesis aimed to build knowledge and understanding of the FFE and its relationship with eating behaviours and obesity status during early childhood (2.0 – 5.0 years) in Australia. In addressing this overall aim, a thorough review of the literature relating to intrapersonal drivers of eating behaviours, the relationship between FFE variables and eating behaviours, and opportunities to modify children's eating behaviours and obesity risk via the FFE has been presented in chapter 2. From this review, specific aims of this thesis have been described in chapter 3 along with details of the methodological approach taken.

Chapter 4 presents results which address the five aims of this thesis, as discussed in chapter 3 to be:

- To determine psycho-social variables associated with children's eating behaviours and the relationship these behaviours have with obesity status in Australian children during early childhood;
- To provide broad scoping descriptive data reflecting the FFE of Australian children during early childhood;
- To examine the intermediary role of children's eating behaviours in the relationship between FFE variables and obesity status;
- To examine the collective influence of FFE factors on children's eating behaviours and obesity status;
- To determine parent's acceptability towards, and behaviour change intentions within, a child feeding intervention.

A summary of the findings obtained have been presented in chapter 5, along with discussion of strengths and limitations of the research conducted. A description of the implications for future research and public health practice have also been presented in chapter 5, prior to proposal of an early childhood feeding intervention to provide clear direction for researchers and clinicians planning obesity prevention interventions. Following the conclusion in chapter 6, appendices have been provided with additional tables summarizing literature reviewed, tools for data collection and additional results.

In approaching this research project, a four-component process in planning health interventions was followed to ensure an outcome-directed, progressive process was implemented. This four-component process further provided a structural framework from which this thesis has been written, as discussed below. [45, 46] To further assist in the implementation of this four-component process, the socio-ecological model has been applied to contextualise the FFE and its relationship with children's eating behaviours and obesity status, as discussed in the section 1.2.2. The behavioural susceptibility theory has also been adopted as an underpinning theoretical perspective from which to understand eating behaviours as potential intermediaries in the inter-relationship between genetic and environmental factors in obesity status (section 1.2.3).

The terms 'early childhood' and 'young children' are used interchangeably in this thesis to refer to children aged 2.0 – 5.0 years. The term 'eating behaviours' is used to refer to observable and/or subjectively reported measures of behaviour related to food intake, while ‘obesogenic eating behaviours’ is used to refer to eating behaviours that confer an increased risk of obesity based on current literature (e.g. increased food approach eating behaviours and/or reduced food avoidance eating behaviours). FFE is used to refer to variables conceptually aligning with the interpersonal and micro-environment elements of the socio-ecological model (section 1.2.2). The term obesity is used to refer to a BMI ≥30.00kg/m^2 in adults, as consistent with standards of the World Health Organisation (WHO), and in children, values corresponding with the age and sex specific values proposed by Cole 2000 and 2007. [47-49]

1.2.1 The 4-component process in planning health intervention

The four-component process in planning health interventions implemented throughout this thesis was proposed by Uesugi and colleagues (2016), as informed by the WHO health education theoretical concepts and strategies, and by Contento’s Procedural Model for Nutrition Education. [45, 46] The components in this process involve:

- Identification of modifiable factors which could act as target behaviours for intervention;
- Identification of potential mediators;
- Selection and justification of theoretical models, and;
- Intervention design.

These components have been used to structure this thesis and are explored in turn as relevant to the relationship between children’s eating behaviours, FFE’s and obesity status.

Additionally, a capacity-building conceptual framework for public health nutrition practice has been integrated into the 4-component process to assist guide this thesis as a capacity-building opportunity within public health nutrition practice. [50] In this regard, capacity building refers to the cultivation and use of transferable knowledge, skill, systems and resources that affect community and individual level changes consistent with public health-related goals and objectives. [50] The schematic model of this integration, as it aligns with the chapters of this thesis are detailed in Figure 1 below. This figure has been used throughout the chapters of this thesis to summarise findings and map progress through each of the component processes and capacity building stages.

Figure 1: Thesis mapping schematic model

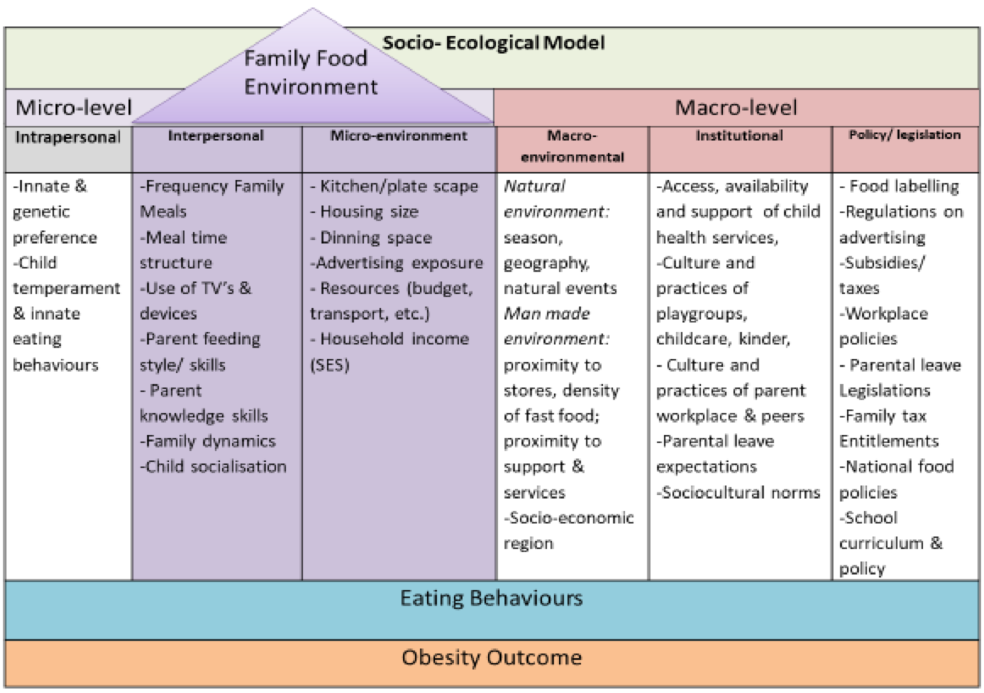
4-component process [45, 46]	**Capacity building stages** [50]		**Relevant thesis sections**
1. *Identification of modifiable factors which could be target behaviours* **2.** *Identification of potential mediators* **3.** *Selection and justification of theoretical model*	**Assessment** **Analysis**	Define needs and analyses problem Determinant analysis	**Chapter 1: Introduction** 1.1 Background: Childhood Obesity 1.2 Overall aim and approach **Chapter 2: Literature review** 2.1 Eating behaviours and obesity in early childhood 2.2 Intrapersonal drivers of eating behaviours in early childhood (Paper 1) 2.3 Family food environments and eating behaviours 2.4 Modification of eating behaviours during early childhood 2.5 Discussion **Chapter 3: Methods** 3.1 Aims and research questions 3.2 Survey 1: Eating behaviours & family food environment 3.3 Survey 2: Intervention opportunities & acceptability **Chapter 4: Results** 4.1 Survey 1 • Paper 2: Eating behaviour traits associated with psycho-social variables and implications for obesity outcomes in early childhood • FFE in Australia and children's eating behaviours • Paper 3: An examination of children's eating behaviours as mediators of parents' feeding strategies on early childhood obesity • Paper 4: Family food environment factors associated with obesity outcomes in early childhood
4 Design intervention	**Action**	Explore strategy options	4.2 Survey 2 (Community Consultation & Acceptability Survey) • Paper 5: Prospects for early childhood feeding interventions: An exploration of parent's concerns and acceptability towards social media intervention opportunities. 4.3 Overall discussion & Recommendations
	Assessment	Implement the strategy portfolio & evaluation (Planning only)	**Chapter 5: Discussion, opportunities for intervention & future direction,** 5.1 Recommendation for intervention design 5.2 Implications for research and practice

1.2.2 The socio-ecological model

A socio-ecological perspective has been taken in this thesis as it recognises that health opportunities are not distributed randomly within populations, but are embedded in social, cultural, economic, environmental, and political circumstances. [51] The socio-ecological model, as based on the works of Rosenkranz (2008) and Brofenbrenner (1977), allows for understanding of variables within levels of overlapping, interactive domains, with downstream, proximal influences on obesity described as the microsystem (intrapersonal, interpersonal and micro-environment), and distal influences on obesity described as the macro-system (macro-environment, institutional and political). [12, 52-54] Each level of the socio-ecological model with its array of domains, uniquely contributes to shaping the FFE. [12, 53, 54]

For this thesis, the FFE was considered to directly comprise interpersonal level variables, underpinned by socio-cultural practices and norms, as well as micro-environment level variables, which impose structural boundaries on food and eating practices with the home. These levels of influence within the socio-ecological model were selected as they were implicated within the literature to exert a significant impact on eating behaviours and obesity status during early childhood (figure 2). [12, 52-54]

Figure 2: The family food environment conceptualised within the socio-ecological model



1.2.3 The behavioural susceptibility theory

As compatible with the socio-ecological model, the behavioural susceptibility theory recognises multiple and interactive domains contribute to the development of obesity. [2] More specifically, the behavioural susceptibility theory posits that obesity results when genetic susceptibility and environmental circumstances interact and 'obesogenic' behaviours ensure. [2] These interactions are likely bi-directional with, for instance, gene expression susceptible to modification within environmental circumstances, and 'obesogenic' behaviours acting as potential catalysts for environmental modification.

2. Introduction

In accordance with the behavioural susceptibility theory, eating behaviours are believed to act as intermediaries between genetic susceptibility and environmental circumstances to underpin obesity status. [2] The literature reviewed in section 2.1 – 2.3 below provides support for this theory and preliminary identification of modifiable factors and potentially mediating variables in accordance with the first two components in the 4-component planning health interventions process (figure 3).

Figure 3: Thesis mapping schematic model – Chapter 1 and 2.2-2.3

4-component process [45, 46]	**Capacity building stages** [50]		**Thesis chapter 1 and 2.1 – 2.3 key points**
1. ***Identification of modifiable factors which could be target behaviours***	**Assessment**	Define needs and analyses problem	**Chapter 1: Introduction** • Childhood obesity is a major public health issue • Family food environments are the central context in which early childhood obesity emerges
2. ***Identification of potential mediators***			**Chapter 2.1 – 2.3: Literature review** • Children's eating behaviours associated with child weight status • Family food environments provide a key context in which obesity status interactions with eating behaviours • Children's eating behaviours appear promising as obesity intervention endpoints
3. *Selection and justification of theoretical model*	**Analysis**	Determinant analysis	**Chapter 3: Methods** 3.1 Aims and research questions 3.2 Survey 1: Eating behaviours & family food environment 3.3 Survey 2: Intervention opportunities & acceptability **Chapter 4: Results** 4.1 Survey 1 • Paper 2: Eating behaviour traits associated with psycho-social variables and implications for obesity outcomes in early childhood • FFE in Australia and children's eating behaviours • Paper 3: An examination of children's eating behaviours as mediators of parents' feeding strategies on early childhood obesity • Paper 4: Family food environment factors associated with obesity outcomes in early childhood
4. *Design intervention*	**Action**	Explore strategy options	4.2 Survey 2 • Paper 5: Prospects for early childhood feeding interventions 4.3 Overall discussion & Recommendations
	Assessment	Implement the strategy portfolio & evaluation	**Chapter 5: Future direction & conclusion** 5.1 Recommendation for intervention design 5.2 Implications for research and practice

2.1 Eating behaviours and obesity

Cross-sectional studies have shown that subjectively measured food approach eating behaviours (food responsiveness, enjoyment of food, desire to drink, emotional overeating) are positively associated with weight status, while subjectively measured food avoidance eating behaviours (satiety responsiveness, food fussiness, slowness in eating, emotional undereating) are negatively associated with weight status. [6, 55-57] In a study of 406 children (aged 7 – 12 years), participating in the Physical Exercise and Appetite in Children Study (PEACHES) or the Twins Early Development Study (London), for instance, each unit increase in food responsiveness, measured using the Children's Eating Behaviour Questionnaire (CEBQ), was associated with a 0.39 increase in BMIz ($p<0.0001$). [5] This study similarly found increases in BMIz associated with CEBQ sub-scales enjoyment of food (0.25 increase BMIz; $p=0.003$), emotional overeating (0.41 increase BMIz; $p<0.0001$), and desire to drink (0.16 increase BMIz; $p=0.04$). [5] Conversely, this study found that for each unit increase in CEBQ sub-scales satiety responsiveness/slowness in eating there was a 0.49 decrease in BMIz ($p<0.0001$) and for girls only, a 0.27 decrease in BMIz ($p=0.008$) in food fussiness. [5] These findings are similar to those reported in a study of 1730 Canadian children, 4 – 5 years of age, which showed a positive linear pattern in weight for CEBQ sub-scales food responsiveness and enjoyment of food, and negative linear patterns in weight for satiety responsiveness, slowness in eating, and food fussiness ($p<0.01$). [7] Carnell, et al., (2008), Croker, et al., (2011), Sleddens, et al., (2008) and Haycraft, et al., (2011) similarly detected trends in both food approach and food avoidance eating behaviours in samples ranging from 3 – 12 years of age using the CEBQ (Appendix 2). [6, 55-57]

While these studies support a relationship between children's eating behaviours and weight status, more recent research has begun to focus on these relationships prospectively. Such prospective studies extend on this casual understanding, to show that variances in eating behaviours precede obesity development in infants and young children, albeit not necessarily in older children. [58-61] Data collected from 1548 infants at 3 months of age during the Gemini Twin Study, for instance, showed that in path analysis enjoyment of food, food responsiveness, satiety responsiveness, and a general appetite rating, were prospectively related to weight standard deviations at 15 months ($B=0.159$, $p<0.001$; $B=0.237$, $p<0.001$; $B=-0.186$, $p<0.001$; and $B=0.142$, $p<0.001$, respectively). [59] While relationships in the opposite direction were also detected (e.g. weight preceding eating behaviours), the direction of these relationships was substantially weaker. [59] Additional analysis of these data extended on this by comparing growth trajectories from 3 months to 15 months of age to show that those with higher food responsiveness (n=121 pairs) and those with lower satiety responsiveness (n=172 pairs) grew faster than their sibling, after controlling for familial confounders. [58] Specifically, twins with higher food responsiveness at 6 months of age were 654g (95% CI, 395-913) heavier than their sibling and at 15 months of age were 991g (95% CI, 484-1498) heavier. [58] Similarly, twins with lower satiety responsiveness at 6 months of age were 637g (95% CI, 438-836) heavier than their sibling and at 15 months were 918g (95% CI, 569-1267) heavier. [58]

Similar relationships have also been noted in children during early childhood with a prospective association seen with poorer satiety responsiveness at 2 years of age and a higher BMIz at 4 years ($n=37$; partial $r = -0.42$, $p=0.015$), although no association between enjoyment of food or food responsiveness and BMI were seen. [60] This lack of relationship between these food approach eating behaviours and BMI may reflect findings of a further prospective study of children 4 – 10 years of age participating in the Generation R Study (n=3331). [61] This study showed that in older children weight status preceded eating behaviours in cross-lag analysis. [61] Specifically, higher BMIz at 4 years of age predicted higher food responsiveness ($B=0.15$, $p< 0.001$) and enjoyment of food ($B=0.09$, $p< 0.001$), as well as less satiety responsiveness ($B=-0.12$, $p< 0.001$) at 10 years of age. [61] These findings are in direct contrast to those obtained in younger children and suggest that while variances in eating behaviours play a role in driving obesity development in infants and young children, as children age the direction of this relationship may alter. [61] This change could be underpinned by alterations in body composition and/or metabolic roles of tissue during childhood, as somewhat supported by the findings of a longitudinal study of 807 children from 6 to 10 years of age. [37] This study showed significant paths from fat mass at age 6 to food responsiveness at age 8 and 10 years ($B=0.05$, $p\leq0.01$ and $B=0.04$, $p\leq0.01$, respectively), and from muscle mass at age 6 to satiety responsiveness at age 8 and 10 years ($B=-0.06$, $p\leq0.01$ and $B=-0.05$, $p\leq0.001$, respectively). [37] As the findings of this study in relation to food responsiveness and fat mass were contrary to what was expected based on the known role of leptin in adults (as a satiety hormone produced by adipose tissue, as discussed in section 2.2.1), it was suggested by the authors that the relationship between body composition and appetite may differ in children from that of adults, due to continuing changes in body composition due to growth. [37]

While similar studies in younger children are not available, the reviewed literature supports that in younger children eating behaviours act as intermediaries in obesity development during this age period, as consistent with the behavioural susceptibility theory. [2, 58-62] This perspective is further supported by the works of Dubois, et al., (2007), who suggests that eating behaviours emerge early in development and show levels of individual continuity during early childhood. [2, 61, 62] This inference was based on a longitudinal study that showed that, among 1498 Canadian children, those who were reported as overeaters at three age points (2.5 years, 3.5 years and 4.5 years) were 6.1 times more likely to be overweight at 4.5 years (95% CI 3.3–11.2, $p=0.05$). [63] Such continuity of eating behaviours early in life can similarly be seen in a study reporting child's appetite ratings at 5 – 6 years and BMI at 7 – 8 years of age. [64] In this study, which used data from the Gateshead Millennium Study (England; n=473 at 6 weeks; n=415 at 12 months; n=491 at 5–6 years), maternal ratings of child appetite made at 6 weeks of age and 12 months of age were correlated with CEBQ sub-scales at 5 – 6 years for enjoyment of food ($r=0.14$, $p<0.01$ and $r=0.24$, $p<0.01$, respectively), satiety responsiveness ($r=-0.14$, $p<0.01$ and $r=-0.19$, $p<0.01$, respectively) and food fussiness ($r=-0.11$, $p<0.05$ and $r=-0.21$ $p<0.01$, respectively), but were not correlated with BMI at 6 – 8 years of age. [64] Additional findings by Dubois, et al., (2007), in the previously mentioned study further showed single-parent status, lower family income, income insufficiency, and having two parents that were overweight or obese, to be related to a child being identified as an 'overeater' at all three age points. [63] These findings additionally reflect concepts of the behavioural susceptibility theory in suggesting that eating behaviours alter with environmental circumstances and may further interact with both developmental stages during childhood and inherent underpinning mechanisms of eating behaviour. [64]

As this review of literature indicates, children's eating behaviours are related to weight status with some evidence that eating behaviours precede this relationship in early childhood. From this perspective, the behavioural susceptibility theory seems plausible to support the intermediary role of eating behaviours in obesity development, under the influence of gene-environment interactions. A summary of studies explored in this section in relation to childhood eating behaviours and obesity during early childhood are provided in Appendix 2. The following section examines the literature in relation to such intra-personal drivers of eating behaviours further before environmental influences are considered in section 2.3.

2.2 Intrapersonal drivers of eating behaviours in early childhood

This section focuses on examining intrapersonal drivers of children's eating behaviours to gain a better understanding of how obesity risk may be modified within the FFE and additionally, how obesity risk may be inequitably distributed within the population. In this regard, the early childhood period offers a unique and critical window for the potential of such alterations in eating behaviours, as it is during this period that eating behaviours are reinforced within socio-cultural contexts to provide a foundation for obesogenic behaviour throughout the lifespan. [65]

That is, young children display innate preferences for sweet and salty flavours and aversions to bitter compounds, such as those found in certain vegetables. [12, 13, 42] Behaviours such as food refusal, 'fussiness,' and food neophobia are common eating behaviours of children during early childhood and are thought to be normal adaptive behaviours, safe guarding a child from new, unfamiliar and potentially harmful foods. [5, 41, 66] In addition to showing relationship with weight status, such eating behaviours further show relationship with children's food preferences. For instance, in a study drawing from two samples of children, aged 16 month (United Kingdom) and 3 – 4 years (Australian; n=1211), food responsiveness was positively associated with preference for non-core foods (3 – 4 year old sample, $\beta=0.10\pm0.03$, $p=0.001$; 16 month old sample, $\beta=0.21 \pm 0.08$, $p=0.010$), while enjoyment of food was positively associated with fruit and vegetable liking (3 – 4 year old sample, $\beta=0.20 \pm 0.03$, $p<0.001$; 16 month old sample, $\beta=0.43 \pm 0.07$, $p<0.001$), and satiety responsiveness (3 – 4 year old sample, $\beta=-0.19 \pm 0.03$, $p<0.001$; 16 month old sample, $\beta=-0.34 \pm 0.08$, $p< 0.001$); slowness in eating (3 – 4 year old sample, $\beta=-0.10 \pm 0.03$, $p=0.002$; 16 month old sample, $\beta =-0.30 \pm 0.08$, $p<0.001$) and food fussiness (3 – 4 year old sample, $\beta=-0.30 \pm 0.03$, $p<0.001$; 16 month old sample, $\beta=-0.60 \pm 0.06$, $p<0.001$) were negatively associated with vegetable liking. [67] Food preferences in this study were obtained via parent reports on a 6-point scale for the three food categories (vegetables, fruits, non-core foods). [67]

In additional analysis of the Australia children in this sample (n=340; 14 months and 3.7 years), it can similarly be seen that children who tried a greater number of fruits and vegetables at 14 months of age had greater liking of fruits at 3.7 years of age ($\beta=0.16$; $p=0.007$ and $\beta=0.14$, $p=0.022$, respectively). [68] This study also showed that fewer vegetables tried at 14 months of age was positively associated with increased food fussiness at 3.7 years of age ($\beta=0.47$, $p<0.001$), and a greater number of non-core foods tried at 14 months of age was associated with a greater liking for non-core foods at 3.7 years of age ($\beta=0.20$, $p=0.001$). [68] Similarly, in a study of 2103 Canadian children aged 2.5, 3.5 and 4.5 years, children classified as 'picky eaters,' (reported on a study specific, maternal-reported questionnaire) were seen to consume less total fats, energy, protein, fruit, vegetables, and meat and alternatives based on a 24-hour food recall, while children classified as 'overeaters' consumed more total energy, and more of each macronutrient. [69] These findings appear consistent with the relationships seen between food approach and food avoidance eating behaviours with weight status, as previously discussed (section 2.1), through potential contributions to energy disequilibrium.

In addition to this, a longitudinal Norwegian study examining taste preferences (sweet, sour, umami, salty, and bitter) and sensitivity (the ability to perceive a taste) from 4 – 6 years of age showed that, in ranking-by-elimination procedures, preference for sweetness increased with age ($F(2,124)=5.437$, $p=0.005$), while preference for bitterness and sourness were stable. [70] Children also showed an increase in sensitivity for sourness ($F(2,112)=3.109$, $p=0.048$) and saltiness ($F(2,125)=6.918$, $p=0.001$), a decrease for sweetness ($F(2,113)=11.925$, $p<0.001$), and stability for umami and bitterness. [70] Interestingly, a negative association was found between sweetness sensitivity and preference for sweetness. [70] The authors of this study concluded that, the weak relationship between taste sensitivity and taste preference suggests that taste preference development is shaped by environmental factors rather than developmental stage. [70] This influence of environmental factors on food and flavour preferences, and similarly eating behaviours, can include socio-cultural contexts or occasions of eating, such that food-cue associations are established to shape food preferences and related food behaviours (e.g. food used as rewards making them preferred; highly palatable foods for celebrations creating positive attention towards these foods; use of pressure or coercion to eat resulting in food avoidance behaviours; section 2.3). [42, 66]

Additionally, early life flavour exposure through feeding practices and in utero exposure have been shown to have influence on taste preferences. This finding is evident in the works of Mennella and colleagues (2001) who conducted a randomised control trial (RCT) involving 46 pregnant women who planned on breastfeeding. The participants in this trial were assigned to 1 of 3 experimental groups; group 1 drank carrot juice during pregnancy and water during lactation; group 2 drank water during pregnancy and carrot juice during lactation; and, group 3 [control group] drank water during both pregnancy and lactation. [71] Approximately 4 weeks after complimentary feeding had been initiated (but prior to the introduction of carrots or juices), infants were fed cereal prepared with water and on a separate occasion cereal prepared with carrot juice. Based on video recordings of the infants, along with mothers' ratings of infant enjoyment (on a 9-point scale), infants who had exposure to carrot flavours in either amniotic fluid (during pregnancy) or breast milk exhibited fewer negative facial expressions to the carrot-flavoured cereal compared with the plain cereal, whereas control infants whose mothers drank water during pregnancy and lactation exhibited no such difference. [71]

While all infants experience in utero flavour exposure, infants who are fed formula will not have the same opportunity as breastfed infants to develop familiarity with flavours which could have an impact on not only food preferences but also eating behaviours, as have been discussed to be intertwined. Studies which have specifically examined the relationship between breastfeeding and eating behaviours are, however, lacking. It is possible that in addition to influencing eating behaviours via food and flavour preferences, functional aspects of formula feeding (such as emptying the bottle) compared with breastfeeding may also play a contributing role in altering eating behaviours that could lead to child weight gain, as discussed in a recent systematic review. [72] In understanding of these early life and environmental influences, it is considered that while children have predispositions to like certain foods and flavours, as inter-related with eating behaviours, the early childhood period is vulnerable to alterations and deviations towards obesogenic behaviours through a complex interplay of a variety of environmental factors (as discussed in more detail in section 2.3). [12, 13]

Current understanding of such alterations and deviations in behaviours that underpin childhood overweight and obesity postulates that variability in appetite systems, reflected in eating behaviours and as interrelated with food preferences, contributes to energy disequilibrium. [22] The term *appetite system* in this thesis is used to encompass both homeostatic drivers of food intake that serve the essential physiological function to motivate eating in order to satisfy energy needs, and hedonic drivers of food intake that provides further motivation to eat in order to fulfil needs for neurological stimuli (such as psycho-social feelings of pleasure, comfort or gratification). [5, 73-75] These appetite systems, while not mutually exclusive aid in theoretically understanding of how appetite operates and are overviewed in section 2.2.1 and 2.2.2, before being explored in more detail regarding their relationship with children's eating behaviours and deviations associated with obesity development in section 2.2.3.

2.2.1 The homeostatic appetite system

The homeostatic appetite system is theorised to involve a range of hormones and neurological signals that aim to satisfy physiological energy needs. This system is complex and traditionally is considered to involve many regulatory hormones and peripheral signals, including cholecystokinin (CCK), glucagon-like peptide-1, and peptide YY; however, only the role of ghrelin, leptin and insulin have been discussed in this review due to their dominant and well-established role in homeostatic appetite. [22, 76-78]

Ghrelin, an orexigenic hormone underpinning hunger, traditionally plays a key role in the homeostatic appetite system. Synthesized predominantly by the stomach, ghrelin binds to the growth hormone secretagogue receptor which is highly expressed in the hypothalamus and brain stem. [76-78] Ghrelin has been reported to increase significantly after birth, peaking around 2 years of age and then decreasing during childhood until the end of puberty, thus suggesting ghrelin plays a role in growth and development. [77, 79]

Leptin is predominately produced in white adipocytes, as a peripheral homeostatic appetite signal, and released to systemic circulation. [78] Given this, plasma leptin concentrations increase in proportion to body fat mass and can be used as biomarker of adiposity. [77, 78] Leptin receptors are highly expressed in the neurons of the hypothalamus and act to stimulate anorexigenic neurons and to inhibit orexigenic neurons. [77, 78] Interestingly, leptin is also produced in the gastric epithelium and locally amplifies gut satiation signals such as CCK. [78] Leptin has also been reported to affect thresholds of sweet taste perception in the tongue, highlighting interactions with the hedonic appetite system, as discussed in the following section. [78]

Similarly to leptin, insulin is believed to have a lipostatic role (a feedback mechanism between adipose tissue deposition and hypothalamic signalling), although its central effects on food intake and energy homeostasis appear less efficient. [76] Insulin is rapidly secreted from pancreatic β-cells following a meal and transported to the brain. [78] There are common hypothalamic targets of leptin and insulin, and evidence of common signal pathways that suggests crosstalk between the two hormones. [76]

Theoretically, the CEBQ sub-scale satiety responsiveness reflects activity of the homeostatic appetite system, with questions such as “My child gets full before his/her meal is finished,” although, the reflection of its relationship with respective homeostatic hormones in clinical studies is somewhat inconsistent, as discussed in section 2.2.3. [80]

2.2.2 The hedonic appetite system

In addition to homeostatic drivers of appetite which operate to fulfil energy requirements, the hedonic appetite system operates in response to the rewarding properties of palatable foods, irrespective of energy needs. [81] Multiple, interconnected structures make up the hedonic appetite system, including (1) the hypothalamus, which, in addition to its homeostatic roles, projects from regulatory circuits to the reward related midbrain dopamine neurocircuitry, (2) the limbic system (amygdala/hippocampus, insula, orbitofrontal cortex, and striatum), which is involved in learning and memory and encodes the value or incentive salience of foods (remembering food-associated stimuli, such as positive feelings related to food, eating and eating occasions), and (3) the cortical (mostly prefrontal) cognitive control system, which enables self-regulation through executive functions. [22, 75, 81-84]

In this regard, hedonic motivation to eat reflects both neurological systems of ‘liking’ and ‘wanting’ of food. [75, 81] ‘Wanting’ refers to the desire to acquire a reward (incentive salience), while ‘liking’ refers to the pleasurable (hedonic) impact of rewards (such as socio-emotional gratification). [81] Whilst neurochemically and neuroanatomically distinct, both liking and wanting are associated with opioid and dopamine signalling in the mesolimbic region. [81, 85, 86] Chronic exposure to highly palatable foods alters the reinforcing value of foods (liking) and weakens inhibitory neural control, triggering learned associations between environmental cues and food rewards (as introduced in section 2.2). Thus, responses to food-associated cues can promote cravings, anticipatory cues of future reward, and food-seeking through activation of the meso-corticolimbic dopamine circuitry. [75, 81, 86]

Theoretically, the CEBQ sub-scales food responsiveness and enjoyment of food captures activation of the hedonic appetite system, with questions such as “Even if my child is full up s/he finds room to eat his/her favourite food” and “My child loves food,” respectively.

The following section explores the relationship between these appetite systems and childhood obesity, as well as the vulnerability of these systems to maladaptation and the relationship between objective measures of appetite and subjective measures of children's eating behaviours.

Text and tables within Section 2.2.3 are a reproduction of the manuscript published in the journal Neuroscience & Biobehavioral Reviews.

The citation is as follows:

Boswell, N., Byrne, R., & Davies, P. S. W. (2018). Aetiology of eating behaviours: a possible mechanism to understand obesity development in early childhood. Neuroscience & Biobehavioral Reviews. doi: https://doi.org/10.1016/j.neubiorev.2018.10.020

Contributor	Statement of contribution
Nikki Boswell	Conception and design of the study (70%) Analysis and interpretation of the data (70%) Drafting and critical review of manuscript (70%)
Rebecca Byrne	Conception and design of the project (15%) Analysis and interpretation of the data (15%) Drafting and critical review of manuscript (15%)
Peter Davies	Conception and design of the project (15%) Analysis and interpretation of the data (15%) Drafting and critical review of manuscript (15%)

2.2.3 Paper 1: Aetiology of eating behaviours: a possible mechanism to understand obesity development in early childhood.

2.2.3.1 Introduction

Obesity is a complex and multifaceted condition that, despite many years of attention in the literature and public health sector, is not yet completely understood and consequently remains an issue of major public health concern. [1] In developed countries one in six children are reported to be overweight or obese, with rates seen to emerges early in life. [87] National data from Australia shows that at 4 – 5 years of age 15.2% of children are overweight and 5.5% are obese. [10] Similarly in the US, at 2 – 5 years of age 12% of children are reported to be obese, with rates progressing to 18% in children 6 – 11 years of age. [88]

At its most simplistic level, obesity, as defined as excessive body fat accumulation, occurs due to an imbalance of energy intake and energy expenditure, i.e. disequilibrium in energy homeostasis. [22] However, to understand obesity beyond this simple equation, attention can be given to exploration of drivers of excess energy intake, such as appetite and eating behaviours. [5, 7, 89] Understanding such drivers of excess energy intake is likely to assist explain differences in rates of obesity within the population, such as groups vulnerable to poverty or other disadvantaged circumstances. [10, 19, 20]

This paper will provide a commentary of the literature related to drivers of excess energy intake, namely appetite and eating behaviours, as likely mechanisms underpinning obesity development in childhood. This paper will further review the relationship between measures of eating behaviours and appetite, as they relate to obesity development. For the purpose of this paper, the term 'appetite' refers to neuro-biological (objective) measures of 'wanting' to eat, encompassing both physiological needs (hunger) and psycho-social desires (emotional and social eating), while the term eating behaviours is used to refer to subjective measures and observable, behavioral responses during eating occasions. Understanding the potential of subjective measures of eating behaviours (such as through the commonly use Children's Eating Behavior Questionnaire [CEBQ] [7]) to reflect appetite mechanisms (objective neuro-biological processes) is likely to be of benefit in advancing understanding of obesity development and consequently obesity prevention initiatives. In this regard, the early childhood period offers a unique and critical window for such alterations in eating behaviours - it is during this period that eating behaviours emerge and are reinforced within socio-cultural context to provide a foundation for obesogenic behaviour throughout the lifespan. [65]

The literature reviewed in this paper will give priority to studies including children during childhood (2 – 12 years), however, studies which encompass older children and adults, will also be considered as relevant to understanding this area of research. The literature included in this commentary focuses on developed, high income countries, since lower income countries experience a complexity of issues likely to affect appetite development and regulation that are outside the scope of this review. Papers included were published in English between 2000 and 2018. This time period was chosen to support consistency and comparability across measurement tools. Studies included in this review have been evaluated, according to the relevant Study Quality Assessment Tools from the National Institutes of Health. [90] These tools comprise a series of questions, which assess several potential sources of bias in a study. Areas covered include assessment of measure validity, the suitability of the study design to address research questions, the generalizability of the sample to the population of interest, and the extent to which key confounders are accounted for in the analyses. Based on this, studies were rated as 'Good', 'Fair' or 'Poor.' [90] All studies were thoroughly evaluated by a single reviewer during the course of PhD candidature.

2.2.3.2 Appetite in early childhood

Appetite systems, as internal processes and interactions that control and regulate appetite, are coordinated by neuroendocrine feedback loops, involving nutrient, hormonal and neurological signals. There are said to be two appetite systems, that, while not mutually exclusive, aid in theoretically understanding of how appetite operates; the homeostatic appetite system, that serves the essential physiological function to motivate eating in order to satisfy energy needs, and the hedonic appetite system, that provides further motivation to eat in excess of energy requirement in order to fulfil needs for neurological stimuli, such as psycho-social desires. [75] Within the homeostatic system circulating hormones, such as leptin and ghrelin, communicate information about peripheral energy levels to the brain, while within the hedonic appetite system, food, as a natural reward, stimulates responses within the mesolimbic dopamine pathway. [75] Whilst the homeostatic and hedonic appetite systems are considered to serve different adaptive purposes, the underpinning hormonal and neuro-biological drives of these systems can be seen to share common pathways and thus an interdependent effect on eating motivations. [77, 78] For example, leptin and insulin, as typically considered homeostatic appetite hormones which signal the hypothalamus, are reported to inhibit hedonic responses to food through action on dopaminergic neurons in the mesolimbic pathway; and ghrelin, as typically considered a homeostatic appetite hormone, has been seen to facilitate hedonic reward processes. [37, 75, 81, 86, 91, 92] The degree to which each system is activated relative to eating is likely to alter depending on the perceived palatability of the food and the individuals physiological energy status. [93]

On this note, although the precise underpinning mechanism by which food stimulates dopamine signalling remains unclear, it appears that these systems are vulnerable to maladaptation and as such act as a pathway to obesity. [75, 94] Current understanding of appetite that underpins childhood overweight and obesity postulates that homeostatic regulators of food intake are chronically suppressed, such that children fail to cease eating once energy requirements are satisfied, and/or hedonic regulators of food intake are chronically heightened, such that children commence and/or continue eating in the absence of physiological energy needs. [5, 73, 74] These disruptions in eating cessation (homeostatic) and commencement (hedonic) may reflect internal susceptibility to dysregulation of appetite systems and/or a vulnerability of these systems to be externally influenced. [95, 96] Influences on appetite systems as they relate to childhood obesity development will be discussed in the following section.

Given these neuro-biological pathways of the appetite systems, clinical measures (e.g. fMRI, blood serum levels) have been used to capture variations in appetite. However, as such use of clinical measures is not always possible or feasible within a research setting, particularly when involving children, alternative behavioural measures have also been used to attempt to capture dysregulations in eating that are likely to result in overweight and obesity. The CEBQ sub-scales, for instance, attempt to provide a subjective, behavioural measures of appetite, with scales such as food responsiveness (e.g. "Even if my child is full up s/he finds room to eat his/her favourite food") considered reflective of eating beyond homeostatic (energy) needs and in order to fulfil hedonic desires, while scales such as satiety responsiveness are conceived to reflect greater attentiveness to the homeostatic appetite system (e.g. "My child gets full before his/her meal is finished,"). [37, 80] Food responsiveness is one of several food approach eating behaviours (e.g. eating behaviours considered to reflect tendencies of wanting, liking and enjoying eating) within the CEBQ which have shown consistent relationship with increased obesity development, while satiety responsiveness, as one of several food avoidance eating behaviours, has shown consistent relationship with reduced obesity development in cross-sectional and longitudinal studies. [5, 7, 64]

2.2.3.3 Influences on appetite systems during early childhood

As consistent with the observed differences in obesity rates among sub-population groups, individual susceptibility to influences on appetite, and consequently maladaptive eating behaviours and the potential for obesity development, appear to vary. [91, 97-100] That is, alterations in appetite hormones (including leptin, ghrelin and cortisol), have been noted as a result of genetic variances, in utero exposures, early life feeding practices, chronic stress, general disadvantaged and discrimination, and inadequate sleep, resulting in variations in hunger and satiation, food preferences/cravings and selective attention toward food. [13, 91, 97-107]

While not all of these factors will be discussed, genetically, the fat mass and obesity-associated (FTO) gene, has received much attention in the literature as the first gene identified through a genome-wide association study (GWAS) to be associated with obesity in humans and highly expressed in areas of the brain, including the hypothalamus, which plays a key role in regulating hormones associated with appetite. [22, 108-119] While primitive GWAS may have carried inherent flaws due to reliance on correlation analysis, repeat measures, and the need for extensive sample size, they provided preliminary insights from which subsequent research has been built. [120, 121] Specifically, research progressions have shown a cluster of single nucleotide polymorphisms (SNPs) in the first intron of the FTO gene to be association with body composition and energy intake in adults and children. [119, 122] In this regard, experimental studies in children and adults, albeit inconsistently, support the action of FTO on appetite by showing that FTO variants are related to increased energy intake or dietary density, as opposed to energy expenditure. [112, 118, 123-125] A study of Scottish children, 4 - 10 years of age (n= 97), specifically showed that the FTO variant (rs9939609) was associated with increased energy intake (P=0.006), independent of body weight, and suggested this to be linked to a hyperphagic phenotype or a preference for energy-dense foods. [123] Similarly, a study of 131 children, aged 4 – 5 years, showed that, in a standard eating behaviour model (palatable food offered under satiety conditions), children with two copies of the lower-risk FTO alleles (rs9939609; TT; homogenous for T allele), ate less than those with one or two higher-risk alleles (AA; homogenous for A allele, and AT; heterogeneous T and A alleles), after controlling for differences in body mass index (BMI). [112] This study concluded that the T allele was protective against overeating by promoting responsiveness to internal signals of satiety. [112] Alternatively, the results of this study could be interpreted to suggests that children with high risk alleles may be vulnerable to external eating cues. This interpretation appears in line with an additional study which showed that in a randomized experiment of 172 children (9 – 10 years), those with high risk FTO alleles consumed more of an advertised food following exposure to respective advertising. [126]

These studies, although informative, only capture a superficial understanding of genetic influences on appetite from which we can understand drivers of excess energy intake. More recent research has further detailed the FTO gene itself to only have a peripheral effect on obesity, with SNPs mediating a relationship between adjacent genes at the locus, such as IRX3. [121, 127] Evidently, obesity-associated SNPs in the first intron of FTO have been associated with expression of IRX3 in the hypothalamus and other brain regions, but not with FTO expression. [127] Further to this complexity, the effect of FTO polymorphisms and/or interactions on obesity does not appear static within the population, rather increasing during childhood years to peak during adolescents, with sex specific effects at some loci. [128-130] This can be seen in a study of 450 obese children (12.6 ± 3.3 years) and 512 normal weight children (17.1 ± 0.8 years), which showed the FTO variant (rs9939609) to be association with obesity (P=0.006, OR 2.033 [1.227–3.369]) only among girls. [111] This finding, however, was not reported across the previously discussed FTO variant studies and the use of repeat analysis to determine sex specific effects increases the risk of error. On this note, although false discovery rate (FDR) was applied in this later study to control for multiple testing, results should still be interpreted with caution; large variances in the mean age between groups of normal weight and obese children is concerning, particularly given the fore mentioned understanding of differential influences of FTO on BMI at various age points during childhood.

Further to this, since genes are understood to interact with environmental factors, homogeneity of the samples must be considered, and confounding factors controlled for. In this regard, in addition to genetic factors underpinning variations in child appetite, in epidemiological and animal models, maternal overnutrition during gestational periods has been suggested to results in offspring with increased appetite drive and higher fat mass (but not lean mass). [116, 117, 131, 132] While these observational studies are limited in their ability to determine the underpinning mechanism of this relationship, and are often further limited due to their ability to control for residual confounding factors [133], an examination of 6057 pairs of mothers and children (6 – 18 years) from two prospective birth cohort studies (ALSPAC and Generation R), has indicated that the relationship between maternal BMI and child weight is due to transposing of genetics rather than intrauterine factors, since no causal effect of maternal gestational BMI on offspring fat mass (DXA) was seen at 10 years of age, once offspring genotype was taken into account. [134] The authors of this study do, however, acknowledge that statistical power in this analysis was limited for some sensitivity tests and further studies are required to obtain more precise (and unbiased) causal estimates.

While experimental studies in humans aren't ethically possible, in rat offspring exposure to 'junk food' (high fat, sugar and salt foods) in utero (through maternal diet) resulted in preference for these foods in early life. [135] While the implications of this research in understanding human development is not precise, it is known that neuronal circuity of the hypothalamus, which integrates regulation of feeding behaviours, is present before birth in humans as well as in rats, thus suggesting a similar outcome to such animal models could be expected in human children. [136-138] This perspective appears consistent with results from an additional study also utilising data from the ALSPAC cohort, which indicated several differentially methylated CpG sites in cord blood of offspring of obese mothers compared with offspring of normal weight mothers. [139] Although this DNA methylation was considered to mediate the relationship between maternal and child weight, statistical power was a concern for this study and the influence on appetite systems were not considered.

Similarly, early life feeding has also been seen to affect appetite and eating behaviours in children, with consequences for obesity development. [140] For instance, in a study of 5590 children (birth – 16 years), longer exclusive breastfeeding duration (i.e. 5 months) was reported to have a substantial impact on BMI trajectory in children with the 'at risk' FTO variant. [141] Specifically, it was reported that at 15 years of age, children with the FTO variant who were exclusively breastfed for at least 5 months, had a predicted reduction in BMI of 0.56 kg/m^2 [95% confidence interval (CI) 0.11–1.01; $P = 0.003$] in boys and 1.14 kg/m^2 (95% CI 0.67–1.62; $P < 0.0001$) in girls, thus further highlighting the potential of sex specific effects. [141] Given the relationship between FTO and appetite discussed in this review, it seems plausible that this protective effect of breastfeeding could be elicited through appetite pathways, particularly since breastfeeding has been seen to have a beneficial impact on appetite via leptin concentrations in breastmilk. [142, 143] Breastfeeding duration has also been associated negatively with DNA methylation of leptin, a non-imprinted gene implicated in appetite regulation and fat metabolism, which may again reflect the beneficial impact of breastfeeding on appetite systems. [106] A study of 109 children (3 – 6 years of age), that retrospectively aimed to determine the association between breastfeeding and subsequent child appetite regulation, compared with bottle-fed human milk, or bottle-fed formula, additionally, showed that children fed human milk in a bottle were 67% less likely to have high satiety responsiveness compared to children directly breastfed, after controlling for co-variates. [144] This finding suggests that the impact of breastfeeding on appetite in children may include mechanical functions in addition to breastmilk composition directly. Further research attention should be given to exploring the breadth of impact of breastfeeding on appetite system.

On this note, those from low socio-economic populations are likely to be particularly vulnerable to maladaptive appetite systems due to a cumulative effect of lower rates of breastfeeding and the direct impact of 'disadvantage.' [145-147] That is, chronic stress and adversity, as commonly experienced by low socio-economic populations, can impact hunger and satiation, food preferences/cravings and selective attention toward food, theoretically to provide compensation for 'distressing' circumstances via dampening of HPA axis activity. [82, 98] This underpinning of chronic stress and adversity on appetite and eating behaviours highlights a potential pathway from which higher rates of obesity in disadvantaged sub-population groups could be exacerbated. [10, 19] To explain this, a 2016 study that experimentally manipulated subjective socio-economic status (SES) in adults has specifically shown that, in four study protocols, the mere feeling of lower socioeconomic status (deprivation) relative to others, stimulated appetite and food intake. [103] These findings were obtained independent of stress related responses (as a common co-factors of low SES) and as such, suggest that simple feelings of deprivation can stimulate appetite through psychological and physiological systems. [103] An additional randomized trial that similarly induced subjective SES among 48 healthy males (24 ± 3 years) further showed that feelings of low subjective SES resulted in lower reported fullness and satiety as well as increase in activation of ghrelin, compared with controls. [148] While the potential of ghrelin to interact with reward systems has previously been discussed, the authors of this study further suggested that subjective feelings of social deprivation may contribute to, or be confused with, physiological signals of energy or nutrient deprivation as consistent with concepts of homeostatic appetite. [148]

Although no similar experimental studies in children are available to show influence of SES on appetite, cross-sectionally in a study of children 2 – 9 years (n= 4406) from multiple European countries, structural equational modelling was implemented to show that the FTO genotype (rs9939609) interacted with SES to influence childhood obesity ($\Delta\chi 2=7.3$, $df=2$, $P=0.03$). [149] This finding, taken in consideration of the suggested mechanism of FTO to influence appetite via mesolimbic dopamine pathway, consolidates understanding of the importance of environment and early life exposures on gene-appetite interactions. That is, while additional research is needed to specifically unpack the relationships between FTO, IRX3 (and/or other unknown genes) and appetite systems, studies in children and adults currently suggested that FTO genotypes attenuate its effect on obesity through association with higher levels of circulating ghrelin as well as with differences in response to ghrelin in brain regions linked with the control of eating and reward. [112, 150-153] Similarly, interactions have been reported between FTO and dopamine receptors, thus highlighting the interaction between the homeostatic appetite system and the hedonic appetite system under the influence of FTO polymorphisms, as a likely pathway to obesity development. [37, 154] Moreover, in distressing environmental conditions and life circumstances, the desires of the hedonic appetite system become heightened, and/or homeostatic signals are confused, under the influence of genetic factors, resulting in an increased drive for energy and/or food reward and likely contributing to explanations of inequitable obesity distribution within populations. Additional studies are needed, however, to further understand the impact of SES on child appetite.

Table 1: Influences on appetite systems during childhood								
Study	**N**	**Age range [years] or mean [SD]**	**% Female**	**Independent Variables**	**Appetite Assessment**	**Quality Rating**	**Major Findings**	**Main limitations/bias**
Genetic Variances								
Cecil, et al. (2008) [123]	97	4 – 10	NR	AP, FTO (rs9939609) + BMI/WC/Skinfold	3 x Test Meal (EI) Indirect calorimetry (EE)	Fair	- AA homogenous was associated with fat mass & increased EI	- Small sample size - % female not reported
Timpson, et al. (2008) [155]	3641	10 – 11	52%	EI, FTO (rs9939609) + BMI	3-day diary Total EI Macro-Intake	Good	- AA homogenous consuming more fat and total EI, independent of body weight	- Imprecise dietary intake measure
Wardle, et al. (2009) [112]	131	4 – 5	47%	EAH, FTO (rs9939609) +BMI	Weighed EI after meal	Fair	- AA homogenous consumed more compared with T & AT	- Small sample size - Non-repeat EAH protocol
Johnson, et al. (2009) [156]	2275	10 - 13	NR	EB + FTO (rs9939609) + FM (DXA)	3-day diary DED (kJ/g)	Good	- No evidence of interaction between FTO and DED at 10 y on FM at 13 y	- Imprecise dietary intake measure - Complete data available for 30% of the original sample
Tanofsky-Kraff, et al. (2009) [125]	289	6 - 19	48%	LOC, FTO (rs9939609) + BMI	Test meal	Fair	- AA/AT subjects, significantly more LOC - No difference in genotype for EI - AA/AT subjects consumed a greater % of energy from fat	- Small sample size - Broad range of ages included - Data collection over 10-year period - Test meal bias
Cole, et al. (2010) [153]	1030	4 - 19	50%	MC4R (18 SNPs), DI, TEE, PA + BMI	Serum 2x 24-hour dietary recall	Good	- SNP rs34114122 has likely functional effects on ghrelin	- Broad range of ages included - Selection of sub-sample unclear
Fabio, et al., (2016) [157]	410	2 - 9	52%	MC4R (rs17782313 & rs17700633), EI, BMI & FM	Serum (PBC) 1 x 24-hour recall WC, Skin fold, Bioelectrical resistance	Fair	- rs17782313 predictor of the increase in the BMI, WC & body fat % - rs17700633 no associations - PBC MC4R higher consumption of fat & lower	- Small sub-sample size - Population stratification risk due to data from 8 countries (results controlled for country) - Imprecise dietary intake measure

Table 1: Influences on appetite systems during childhood								
Study	**N**	**Age range [years] or mean [SD]**	**% Female**	**Independent Variables**	**Appetite Assessment**	**Quality Rating**	**Major Findings**	**Main limitations/bias**
							consumption of carbohydrates. No association protein	- Repeat statistical analysis
Adise, et al. (2018) [158]	59	7 - 11	54%	DI, fMRI & BMI	3 x DI (typical consumption, overindulgent test condition & EAH)	Fair	- mPFC & child BMI predicted variance in baseline meal - mPFC for anticipating food increased intake at the baseline meal - greater mPFC response for anticipating food ate more at buffet meal	- Small sample size - Large number of ineligible/excluded children - Imprecise dietary intake measure - Sample bias/unclear recruitment - Protocol limitations (difficulty conducting fMRI in children)
Early life exposures (breastfeeding, in utero)								
Miralles, et al. (2006) [142]	28	2	57%	BF, Maternal Serum + BMI	BF	Fair	- Breast milk leptin at 1-month lactation negatively correlated with infant BMI at 18 and 24 months of age	- Small sample size - Statistical limitations - Cofounding variables not controlled - Unclear recruitment
Schuster, et al. (2011) [143]	23	0.5	43%	BF, Maternal Serum, Maternal BMI + BMI	BF	Fair	- Negative association between breast milk leptin during 1st week after delivery & infant weight gain from the end of 1st 6-months	- Small sample size - Large loss to follow up - Unclear recruitment - Cofounding variables not controlled - Unclear anthropometric measurement methods - Statistical limitations
Beijers, et al. (2013) [97]	193	1	47%	BF, co-sleep, Stress Procedure, Cortisol	BF	Fair	- More weeks of BF predicted quicker cortisol recovery	- Small sample size - Imprecise exposure measures (parent retrospective report) - Non-generalizable sample (high educated) - Non-repeat cortisol

Table 1: Influences on appetite systems during childhood								
Study	**N**	**Age range [years] or mean [SD]**	**% Female**	**Independent Variables**	**Appetite Assessment**	**Quality Rating**	**Major Findings**	**Main limitations/bias**
								measures
Obermann-Borst, et al. (2013) [106]	120	1.4	42%	LEP, BF + BMI	BF	Fair	- Duration of BF negatively associated with LEP methylation	- Small sample size - Repeat statistical tests - Methodological protocol limited (DNA extraction from blood not tissue) - Potential recall bias
Wu, et al. (2017) [141]	5590	Birth - 16	49%	BMI, FTO (rs9939609) + BF	BF	Good	- Exclusive BF ≥5months reduce BMI via FTO	- Opportunity to control for additional cofounding variables
Disadvantage/stress/emotional disfunction								
Foraita, et al. (2014) [149]	4406	2 - 9	48%	FTO (rs9939609), SES + Obesity (BMI, Waist: Hip, Skinfold)	EI (24hr-recall) Macro-Intake	Good	- SES interacts with FTO to effect childhood obesity	- Population stratification risk due to data from 8 countries (results controlled for country)
Advertising								
Gilbert-Diamond, et al. (2016) [126]	172	9 – 10	51%	FTO (rs9939609), Advertising (RCT)	Pre-load Meal Condition 1: Toy advertisement Condition 2: Food advertisement EAH	Good	- Significant interaction between the FTO genotype & food advertisement exposure with advertised food consumption	- Small sample size - Non-generalizable sample (high educated) - Non-repeated experimental protocol

AP= appetite; BF = Breastfeeding; BMI = Body Mass Index (crude, z-scores or percentiles); CES-D = Center for Epidemiologic Studies Depression Scale; DEBQ = Dutch Eating Behaviour Questionnaire; EAH = Eating in the absence of hunger; DED = dietary energy density; EB = Eating behaviours; EE = Energy Expenditure; EI = Energy Intake; FM = Fat mass; FFBS = Family Food Behavior Survey; LEP = Leptin; LOC = Loss of control; mPFC = medial prefrontal cortex; Not reported; PBC = Peripheral blood cells; PA = Physical activity; SES = Socio-economic Status; TEE = Total energy expenditure, WC = waist circumference

2.2.3.4 Relationship between appetite and eating behaviour measures

As can be seen from the discussion thus far, appetite systems are complex, interdependent and vulnerable to maladaptation. Consequently, the manifestation of appetite systems into observable (and subjectively measurable) eating behaviours, as obesity intermediaries, is likely to be equally as complex. In the following section, literature focusing on the relationship between subjective measures of eating behaviours, such as those captured within the objective measures of appetite, particularly the CEBQ, and obesity will be discussed. Understanding the relationship between subjective measures of eating behaviours and appetite systems, as well as the relationship with obesity development, may highlight opportunities to better target obesity prevention intervention, particularly through manipulation or restructuring of appetite systems in beneficial ways.

2.2.3.5 Eating behaviours and appetite variances

Much like obesity, which is considered to involve as much as 70% genetic variances, subjective measures of eating behaviours (the Children's Eating Behaviour Questionnaire, CEBQ; three-Factor Eating Questionnaire, TFEQ-R21; Dutch Eating Behaviour Questionnaire, DEBQ; The Eating Inventory; EI; eating in the absence of hunger; EAH) have been reported to capture hereditable aspects of appetite. [3, 159-164] A study of 2,402 infant twin pairs (8 months of age), specifically indicated that, 53% (95% CI 0.43, 0.63) of the CEBQ sub-scale enjoyment of food was hereditable, as was 59% (95% CI 0.52, 0.65) of the scale food responsiveness, 72% (95%CI 0.65, 0.80) of the scale satiety responsiveness, and 84% (95% CI 0.79, 0.86) of the scale slowness in eating. [113] This heritability of eating behaviours is similar to that reported in a sample of twins 8 – 11 years of age (n=5435 pairs), which showed satiety responsiveness to be 63% (95% CI 0.39, 0.81) heritable and food cue responsiveness (enjoyment of food) to be 75% (95% CI 0.52, 0.85) heritable. [165] Additionally, this study indicated shared environment and non-shared environment to explain 21% (95% CI 0.0, 0.51) and 16% (95% CI 0.10, 0.21) of the variance in satiety responsiveness, and 10% (95% CI 0.0, 0.38) and 15% (95% CI 0.10, 0.18) of food cue responsiveness, respectively. [165] Although this ability of subjective scales to seemingly capture hereditable aspects of appetite appears promising in understanding the relationship between eating behaviours, appetite and obesity development, results should be interpreted with caution due to the limitations of twin studies to be generalised to the wider population, the risk of inflated heritability due to the shared environment being more similar for monozygotic than for dizygotic twins, and other measurement bias related to parental reporting of eating behaviours of twins. On this note, caution should further be taken when interpreting the results of such hereditability studies since genetic factors associated with obesity are likely to differentially influence behavioural responses (e.g., eating behaviours) to environmental context, as has been discussed. [166]

Despite these limitations, studies that have specifically aimed to develop understanding of the relationship between genetic factors, children's eating behaviours and obesity have largely, as similar to previous discussion, focused on the role of FTO in increased energy intake (as opposed to energy expenditure) and food preferences. For instance, a study of 131 children 4 – 5 years of age, investigating the relationship between FTO alleles (rs9939609) and food intake on a standardized eating behaviour task (eating in the absence of hunger; EAH), found that children in the AA group (homogenous for A allele), had 25% higher food intake compared with TT (homogenous for T allele) group. [112] This higher intake was concluded to reflect sensitivity to satiety. [112] Wardle, et al., (2008) similarly showed that, in 3337 twin children (8 – 11 years), the at-risk FTO variant (AA homozygotes; rs9939609 SNP) had significantly reduced satiety responsiveness scores, but there was no significant effect on enjoyment of food, as may suggests a dominant effect of FTO on homeostatic appetite. [151] Importantly, this study found that the association between the at-risk variant (AA genotype) and increased adiposity was in part mediated through satiety responsiveness, as is consistent with the gene-environment perspective (the behavioural susceptibility theory) in which behavioural responses play an intermediary role in obesity development. [96, 151] It was similarly reported in a more recent study of 178 children, 9–10 years of age, that decreased satiety responsiveness and increased food responsiveness were each partially mediated by positive associations between the FTO high-risk genotype and increased BMI z-score (P-value for each indirect effect <0.05), although this did not translate into statistically significant differences in short term energy intake. [167]

Moving beyond the dominance of FTO in this gene-environment theory, a study of 221 overweight/obese Chilean children (9.5 years) investigating the associations between eating behaviour with the gene variant rs17782313 near the melanocortin-4 receptor (MC4R), similarly showed statistically significant associations between the gene variant and CEBQ sub-scales enjoyment of food (P=0.03) as well as satiety responsiveness (P=0.01). [168] This result was specifically reported to show concordance with the known biological function of MC4R, (playing a central role in energy homeostasis through its action on leptin via the hypothalamus and central nervous system), with respect to the association with satiety responsiveness (which decreased with the gene variant), while associations with enjoyment of food (which increased with the gene variant) likely reflects the role of leptin in modulating neural activation in key striatal brain regions related to food reward and satiety signals during food intake, as more inclined with the adaptive function of the hedonic system. [168, 169] These relationships are further consistent with the relationship between MC4R and obesity in children, as reported in a recent systematic review and meta-analysis ($P < 0.05$), and appear further consistent with the findings of an additional study of rs17782313 which showed associated between the gene variant and higher consumption of dietary fat ($P=0.001$) and lower consumption of carbohydrates ($P=0.005$) in a study of 410 children 2 – 9 years based on parent reported 24-hour recall. [157, 170]

On this note, a study of children 3 – 4 years of age (n = 354) that examined polymorphisms in genes that control dopamine availability, similarly implicated the role of dopamine not only in relation to overeating, but also to food preference. [171] That is, in boys the long allele gene variant MAOAu-VNTR was associated with higher intake of lipid dense food and sugar dense food, however, these associations were not seen in girls and body weight was not measured. [171] While an additional study of Chilean children (n=258, 8 – 14 years), implicated polymorphism rs1800497 (or TaqI A1 allele), in the dopamine receptor gene, to be associated with higher scores on satiety responsiveness and emotional undereating sub-scales in obese girls, and higher scores of enjoyment of food subscale in boys, a recent systematic review and meta-analysis determined this SNP not to be associated with childhood obesity and thus the gene approach in this study should be interpreted cautiously. [172, 173] Interestingly, Fildes, et al., (2015) showed in a cross-sectional study of children 16 months – 4 years, that vegetable liking was positively associated with enjoyment of food and negatively related to satiety responsiveness, slowness in eating, and food fussiness, while fruit liking was positively associated with enjoyment of food, and negatively associated with satiety responsiveness, food fussiness, and slowness in eating. [67] Food responsiveness was not related to fruit and vegetable liking, but importantly, was positively associated with noncore food preference (e.g. energy dense, nutrient poor foods such as chocolate or chips), as may reflect the ability of this subjective measures to loosely capture underpinning neuro-biological elements of appetite. [67]

In a similar regard, food cue-exposure on measures of orofacial reactivity, self-rated pleasantness and food preference, has also been examined in overweight and normal-weight children, 6 –11 years of age. [174] In this study children were exposed to the smell and sight of high and low-energy density food stimuli and to non-food stimuli during pre- and post-prandial states. Facial and verbal responses were videotaped and parent reported CEBQ sub-scales were collected. Orofacial reactivity to food cues (measured using odorant solutions to which the child had to indicate subjective liking and wanting), as structurally linked to the mesolimbic reward system, was associated with child BMI along with food responsiveness, emotional overeating, and desire to drink. [174] These findings suggest that orofacial responsiveness, may reflect sensitivity to energy-dense food reward cues in overweight children and of signalling of anticipatory liking, as a maladaptation of the hedonic appetite system and a potential risk for the development of obesity. [174]

In similar efforts to determine underpinning neural variations related to appetite and obesity, techniques such as functional magnetic resonance imaging (fMRI), have been used to understand how appetite modulates brain activity. [175] Relying on changes in blood flow to make associations with neuron activation, fMRI aims to detect levels of reward from food consumption and anticipated food intake, as expected to differ between normal weight and obese individuals. [175] Conversely to this expectation, however, a study of healthy weight and overweight children aged 6 – 8 years (n = 18), using fMRI scans while anticipating and receiving tastes of chocolate milkshake, showed no differences between weight status for brain response to a visual food cue. [176] Interactions were, however, seen between CEBQ sub-scale scores and weight status on brain response to taste. [176] That is, overweight children showed greater brain response to the taste of a milkshake than healthy weight children, although those with higher scores on enjoyment of food, food responsiveness, and emotional over-eating showed more diminished response. [176] This finding could suggest that those with diminished brain response may exhibit greater food approach eating behaviours (enjoyment of food, food responsiveness and emotional over-eating), in order to achieve the same level of neural ‘reward’ – thus eating beyond homeostatic need and increasing the risk of obesity.

In an additional study of 38 children 8 – 13 years of age, resting state fMRI was also used to show that as functional connectivity imbalance is increasingly biased toward impulsivity, food approach behaviours increase, food avoidance behaviours decrease and, as consistent with the literature, adiposity increased. [74] These finding could again imply that food approach eating behaviours reflect underpinning drivers for neurological stimuli. Somewhat consistent with this, a study examining self-regulatory behaviour through executive function (including measures of inhibition, attention shifting, decision making and delayed gratification), in 1657 children aged 6–11 years, showed expected negative associations between executive function and the obesity associated food-approach behaviors, desire to drink, food responsiveness, and restrained eating, but, only in girls. In boys, executive functions were not associated with any of the eating styles. [177] In interpreting this result, however, it should be emphasised that fMRI attempts to capture very specific neurological variations in relation to eating behaviours and appetite, whereas subjective, behavioural measures such as CEBQ attempts to capture behavioural variations in eating that may reflect a diversity of underpinning genetic, developmental, psychological and environmental influences, as have been discussed to impact appetite. Given these significant differences in measurement tools, it is unsurprising that fMRI and CEBQ scales tend to correlate poorly, thus the relationships reported may lack validity. [175]

A recent experimental study has, however, attempted to compensate for such measurement issues between fMRI and subjective measures of eating behaviours, through the addition of test meal protocols. [158] Specifically in this study, 59 children, 7 – 11 years of age, participated in a fMRI anticipatory and reward protocol (food, money, neutral), in addition to differing measures of food intake (typical consumption [baseline meal], overindulgent test condition, and standardised EAH). [158] Results from this study were comparable with those utilising the CEBQ, such as greater medial prefrontal cortex response for anticipating food (compared to money) was positively correlated with children typical intake as well as intake in overindulgent conditions (palatable buffet meals). [158] Similarly, response in the dorsolateral prefrontal cortex for winning food (compared to money) was also positively correlated with intake during overindulgent conditions and EAH. [158] These relationships were reported independent of weight status. While there is no ideal method of assessing eating behaviours or appetite, this study implemented a robust protocol that alleviated reporting bias, particularly parental social desirability, as can be introduced in relation to the CEBQ, while similarly indicating increased food approach-style tendencies were related to neurological reward pathways. [158] Nonetheless, the CEBQ, has demonstrated good internal consistency, reproducibility and construct validity in multiple studies and consequently is considered useful tool to comprehensively evaluate children's eating behaviours, regardless of the aetiology. [7, 35, 57, 80, 175, 178, 179]

As has been discussed, appetite pathways reflected in eating behaviours may offer an important measure of obesity risk and as a modifiable obesity intermediary in ‘high risk’ groups. Epidemiologically, Dubios and colleagues (2007), have shown this intermediary marker of risk by reporting ‘overeating’ to be longitudinally (at 2.5, 3.5 and 4.5 years) related to single-parent family status, lower family income, income insufficiency, and having overweight or obese parents. [63] Consistent with this, higher appetite restraint (defined from a 2 factor solution of CEBQ, comprising the sub-scales food fussiness, enjoyment of food, slowness in eating, and satiety responsiveness) at 7 years of age was associated with higher maternal age and educational level, a 2-parent family and no siblings, and more sedentary lifestyles at 4 years old. [180] Higher appetite restraint was also associated with lower child and maternal BMI and waist circumference at 4 years of age. In contrast to this, higher appetite disinhibition was associated with lower maternal educational, having a 1-parent family, more sedentary behaviours, and higher BMI and waist circumference at 4 years old. [180] These studies did not, however, examine the broader range of eating behaviour traits captured in the CEBQ, as associated with obesity development, thus leaving much about the relationship between demographic, intrapersonal and psycho-social variables with eating behaviours unknown.

Table 2: Eating behaviours and appetite variances in children								
Study	**N**	**Age range [years] or mean [SD]**	**% Female**	**Independent variables**	**Eating Behaviour Assessment**	**Quality Rating**	**Major Findings**	**Major limitations/bias**
Genetics								
Wardle, et al. (2008) [151]	3337	8 – 11	50%	FTO (rs9939609), EB + BMI	CEBQ	Good	- AA homozygotes had significantly reduced satiety responsiveness (partially mediated through FM)	- Diverse range of EB sub-scales not measured - Potential insufficient sensitivity of EB measure
Valladares, et al. (2010) [168]	221	9.5	45%	MC4R (rs17782313), EB + BMI	CEBQ TFEQ	Fair	- rs17782313 variant associated with satiety responsiveness & enjoyment of food scores	- Small sample size - No adjustment for multiple tests - Population stratification bias (by ethnicity; results controlled for by family-based associations) - Cofounding variables not controlled
Galvão, et al. (2012) [171]	354	3 – 4	43%	DI, MAOAu-VNTR	2 x 24-hour recall	Fair	- MAOAu-VNTR associated with higher intake of lipid-dense foods	- Small sample size - Limited statistical power - Protocol bias (child may have limited control of food selection)
Ho-Urriola, et al (2014) [181]	377	6 – 12	51%	MC4R (rs17782313), EB + BMI	CEBQ EAH	Good	- CC genotype had higher enjoyment of food higher & lower satiety responsiveness	- Small sample size - Broad range of ages included - Protocol bias (parents present during EAH test; only normal-weight children participated in EAH protocol) - Small control group (n=5)
Llewellyn, et al. (2014) [182]	2258	9.9 (±0.8)	53.3%	PRS, EB + BMI	CEBQ	Good	- PRS was negatively related to satiety responsiveness	- Parent measured child anthropometrics
Emond, et al. (2017) [167]	178	9 - 10	51%	FTO (rs9939609), EB + BMI	CEBQ EI	Fair	- AA homozygous related to increased BMI via	- Small sample size - Recruitment bias

Table 2: Eating behaviours and appetite variances in children								
Study	**N**	**Age range [years] or mean [SD]**	**% Female**	**Independent variables**	**Eating Behaviour Assessment**	**Quality Rating**	**Major Findings**	**Major limitations/bias**
							decreased satiety responsiveness & increased food responsiveness	(parents seeking paediatric support) - Limited sample generalisability (ethnically homogenous) - Parent report PA
Monnereau, et al. (2017) [183]	3,031	4 (±0.1)	51%	GWAS (15 SNP), EB + BMI	CEBQ	Good	- 15 SNP-score not associated with the CEBQ sub-scale	- Limited sample generalisability (non-respondents low SES, younger mothers) - Not all SNP's available - Potential limited power
Obregón, et al. (2017) [172]	258	8 – 14	44%	TaqI A1 (rs1800497), EB, Food Value + BMI	CEBQ EAH TFEQ FRVQ	Fair	- TaqI A1 allele was associated with higher scores on satiety responsiveness & emotional undereating in obese girls, & higher enjoyment of food in boys	- Small sample size - Convenience sample recruited
Neurological								
Soussignana, et al. (2012) [174]	150	6 - 11	NR	Orofacial reactivity, CEBQ + BMI	2-choice food preference test CEBQ	Fair	- Orofacial reactivity to food cues was associated food responsiveness, emotional overeating, and desire to drink	- Small sample size - Causal relationship - Cofounding variables not controlled
Groppe, et al. (2014) [177]	1657	6 - 11	52%	EF, Fluid intelligence,	CEBQ	Fair	- Low hot EF associated with food approach EB in girls	- No adjustment for multiple tests - Protocol limitations (measures on 5 EF tasks) - Cofounding variables not controlled

Table 2: Eating behaviours and appetite variances in children								
Study	**N**	**Age range [years] or mean [SD]**	**% Female**	**Independent variables**	**Eating Behaviour Assessment**	**Quality Rating**	**Major Findings**	**Major limitations/bias**
Chodkowski, et al. (2016) [74]	38	8 – 13	46%	rsFC (Impulsivity) + BMI	CEBQ	Fair	- Food approach behaviours increase & food avoidance behaviours decrease with increasing impulsivity-biased imbalance	- Small sample size - Causal relationship - Opportunity to control for additional cofounding variables - Repeat statistical tests
Bohon, et al. (2017) [176]	18	6 - 8	72%	Taste exposure, EB, fMRI + BMI	CEBQ	Poor	- Obese children showed greater brain response to taste	- Small sample size - Limited sample generalisability (high SES, sex bias) - High exclusion rate - Protocol limitations (difficulty conducting fMRI in children) - Lenient statistical threshold - Non-repeat experimental protocol
Early life exposures (breastfeeding)								
DiSantis, et al (2011) [144]	109	3 – 6	51%	EB, BF + BMI	Feeding History CEBQ	Fair	- Children fed breast milk in a bottle less likely to have high satiety responsiveness compared to directly breastfed children	- Small sample size - Protocol limitation (retrospective design) - Recruitment bias (parents seeking paediatric support) - Limited sample generalisability (high maternal education, high income, high breastfeeding rates)

BEBQ = Baby Eating Behavior Questionnaire; BF = Breastfeeding; CEBQ = Children's eating behavior questionnaire; CFQ = Child Feeding Questionnaire; CHAOS = Chaos, Hubbub, and Order Scale; DI = Dietary intake; EAH = Eating in the absence of hunger; EB = Eating Behaviours; EF=Executive function; EI = Energy Intake; FM = Fat mass; FRVQ = Food Reinforcement Value Questionnaire; GWAS= Genome-wide association study; FM = Fat Mass; PA = Physical activity; PRS = Polygenic risk score; rsFC = Resting state functional connectivity; TFEQ = Three Factor Eating Questionnaire; TV = Television

2.2.3.6 Discussion and implications for childhood obesity prevention

Whilst this review is far from exhaustive, it highlights the complex influences that can be attributed to variances in appetite systems that appear to underpin eating behaviours and consequently obesity development. Understanding these variances in obesity development pathways provides a more thorough understanding of the relevance of gene-environment interaction theory and the opportunity for environmental change to effect these underpinning appetite systems in obesity protective ways. [96] The opportunity to readily use subjective and observable measures of eating behaviours to monitor such changes in appetite systems further holds much potential for obesity prevention initiatives and public health monitoring. On this note, while making the adaptive distinction between the homeostatic and the hedonic appetite systems has been theoretically convenient for the purpose of this paper, in reality, and as evident through the literature reviewed, these appetite systems are interdependent and as such maladaptation within one system is likely to have a concurrent impact on the other system. With this in mind, a holistic approach to supporting ‘healthful’ appetite systems and eating behaviours is important to promote both energy equilibrium as well as a healthful, hedonic relationship with food.

Given that appetite systems appear vulnerable to maladaptation in response to environmental circumstance, the associated obesity risks are considered not to be distributed evenly within society, with both those with genetic susceptibilities and those in disadvantage circumstances likely to be more responsive to external food cues and/or less responsive to internal cues of hunger and satiety. In modern, western society external food cues which stimulate the appetite and eating behaviours are directly embedded within the disproportionate availability, variety and presence of energy dense, highly palatability foods. [84] Food cues are also indirectly embedded within public policies, the agricultural, food and grocery industry, pricing strategies, and tax and economic structures and incentives, which make it extremely difficult to supress excessive hedonic cues and make food choices based on homeostatic needs. [84, 184] This exposure to food cues is even more prominent in disadvantaged areas, thus subjecting vulnerable populations to a higher density of food cues and less equitable food environments to further manipulate appetite systems, eating behaviours and obesity risk. [184] Thus, for obesity prevention intervention to be effective, macro-level intervention that addresses the disproportionate and excessive exposure to food cues is necessary, in addition to micro-level strategies, such as those that occur at the interpersonal level and within the family food environment which play an important role in establishing healthful eating behaviours in young children.

Key Highlights
- Maladaptation of appetite systems drives excess energy intake and contribute to childhood obesity risk. - Gene-environment interactions are important in obesity risk, with behaviour (e.g. eating behaviours) playing an intermediary role. - Early childhood is an important time for obesity prevention, as this is a prime time in which gene-environment interactions contribute to maladaptation of appetite systems. - Gene-environment interaction that contribute to maladaptation of the appetite systems helps explain differing rates of obesity within sub-population groups. - Subjective measures of eating behaviours provide a convenient and general measure of multiple, interconnected and complex appetite systems and obesity risk. - Macro-level strategies are needed to minimise determinantal gene-environment interactions.
Research Gaps - Genetic contributions to obesity and appetite requires ongoing, high quality, research with much unknown regarding gene and gene interactions. - Gaps in understanding of gene-environment interactions (epigenetics) limits ability to appropriately target obesity prevention. - The intergenerational effect of breastfeeding and in utero-life from a neuro-biological perspective requires additional attention in regard to impact on appetite systems and obesity. - Future attention should be given to the potential of appetite/eating behaviours to predict future obesity, thus supporting use of such measure for early identification of obesity risk and measure of effectiveness of obesity prevention. - Priority should be given to determine the feasibility of modifying appetite/eating behaviours, particularly in children who are genetically susceptible to obesity.

2.2.3.7 Conclusion

As has been described, the genetic, neurobiological and epigenetic underpinnings of appetite which appear to manifest in eating behaviours, as theoretical obesity intermediaries, is complex, interdependent and not yet understood in its entity. From the literature reviewed it appears that research focusing attention on demographic, intrapersonal and psycho-social variables that influence appetite and eating behaviours is further warranted in order to (1) better understanding differences in rates of obesity within the population, (2) to determine opportunities for targeted obesity prevention initiatives and justifiably measure change in eating behaviours as a marker of appetite change and reduced obesity risk, and (3) to inform future clinical research aiming to further identify and understand underpinning mechanisms of childhood obesity.

2.3 Family food environments and eating behaviours

While intrapersonal factors can be seen to play a significant role in the emergence of children's eating behaviours, environmental factors are similarly likely to play a significant role. A review of the literature relating to such environmental influences as relevant to children's eating behaviours and obesity status in early childhood has been presented in the following section.

Despite young children spending an increasing amount of time in care outside of the home (with 55% of children 3 – 5 years of age spending an average of 15 hours per week in childcare, kindergarten informal care etc.; with rates differing greatly with parent employment, child age, and remoteness), the family home is still considered to play a pivotal role in shaping children's obesity risk, through consistent interactions with intrapersonal factors. [12, 44, 185-187] In this regard, the FFE, as contextualised within the socio-ecological model to comprise interpersonal (socio-cultural) influences imposed by parents as well as the micro-environment influences within the home which impose structural boundaries on food and eating behaviours, provides a central context in which influence is exerted on children's eating behaviours and obesity risk. [12, 188-190] This importance of the family home in childhood obesity can be seen in the findings from a multicomponent, multilevel obesity prevention intervention involving 1726 children (4 – 12 years; intervention group) from 4 preschools and 6 primary schools in the low socio-economic region of Colac, Victoria. [191] Specifically, the results of this study showed that variation between household environments (included the number of TV in the house, the incidence of rules for TV viewing, and the number of nights per week that the TV is usually on during evening meal times) was the largest contributor to the percentage of unexplained change in child BMIz (59%) following a community level obesity prevention intervention, compared with contributions from the individual (23%; dietary intake and sedentary behaviour) and school levels (1%; written healthy eating and physical activity policy). [191] This finding is similar to the results reported from a multi-level obesity prevention intervention, involving children aged 2 – 8 years (n=8371, 27 communities; US), which, despite showing significant differences in overweight and obesity prevalence in intervention children compared with control children (−3.90% [95% CI, −6.32% to −1.47%] vs 0.05% [95% CI, 0.00% to 0.11%]; *P* = .02), was not able to attribute results to individual level variables (including sleep time [hours/ day], physical activity level, fruit and vegetable intake, water consumption, and sugar-sweetened beverages consumption) thus suggesting the importance of environmental level strategies. [192] This perspective is further supported by a recent literature review of multicomponent, environmental childhood obesity prevention interventions, which suggested that focusing on social and cultural environments, such as those within the family home, along with physical, political and economic environments may be more effective in preventing obesity than individual level strategies which have shown limited success. [193]

In line with this, it has been seen that genetic predisposition towards obesity (as consistent with discussed in section 2.2.3) are more strongly associated with child BMI in more obesogenic home environments. [44] That is, in a study of 925 families with twins participating in the Gemini Twin Study (mean age 4.1 years ± 0.4), children living in higher-risk home environments (based on composite scores capturing food, physical activity, and media-related influences in the home) compared with those living in lower-risk home environments (86%; 95%CI, 68%-89% verse 39%;95%CI,21%-57%, respectively), had higher heritability of BMI standard deviations. [44] While heritability studies have their limitations, these findings reiterate the importance of the FFE in modulating intrapersonal predispositions towards obesity and thus, the opportunity to reduce obesity status via modification of FFE’s (section 2.4).

As mentioned, it has been estimated that environmental factors such as those within the FFE, account for approximately 45% of variance in children’s eating behaviours and 28% of variance in child BMI. [3, 4] The impact of such environments on children’s eating behaviours can be seen early in life with a study of infant twin pairs (n = 2402 pairs; mean age, 8 months), showing shared environment to explain between 16% and 45% of variance in eating behaviours. [113] A study of twin pairs 8 – 11 years of age (n=5435 pairs), similarly found shared environment influenced 21% (0–51%) of satiety responsiveness, and 10% (0–38%) of food cue responsiveness, while non-shared environment influenced 16% (10–21%) of satiety responsiveness and 15% (10–18%) of food cue responsiveness. [165] Conversely, both emotional undereating and emotional overeating have been explained almost exclusively by shared environments (emotional overeating: C = 90%, 95% CI: 89%-92%; emotional undereating: C = 91%, 95% CI: 90%-92%). [194] While food fussiness is described to be equally explained by genetics and shared environment (0.46; 95% CI: 0.41-0.52 and 0.46; 95% CI: 0.41-0.51, respectively). [195] Dubios, et al., (2013), explains that, based on variance estimates in twins aged 2.5 and 9 years of age (n=692), the relative influence of genetics on eating behaviours decreases as children get older, thus environmental influences become increasingly important. [196] Consequently, it was concluded that familial context has considerable potential to influence the development of healthy eating behaviours and habits throughout childhood. [196]

As these findings indicate, the range of conceptualised eating behaviours are likely to have differential vulnerabilities to alteration within the FFE, that further vary with child age and other predisposing factors (as discussed in section 2.2.3). On this note, it can be considered that the FFE comprises both shared and non-shared environmental elements with regards to the differential emergence of children's eating behaviours. [197] For instance, it has been reported that aspects of the FFE such as parental perceptions of responsibility for child feeding and monitoring of child eating, have significant familial correlations, thus suggesting these aspects of the FFE constitute shared elements. [198, 199] By contrast, it is understood that within the FFE mothers implement differential pressure on their children to eat, exhibit differential levels of weight concern towards their children, and show tendencies to differentially restrict children's food intake, thus constituting non-shared elements of the FFE. [198, 200-202] While non-shared environmental influences on children's eating behaviours are additionally likely to extend beyond the FFE, specific details of these elements are not identified in the literature. [203]

Given this importance of the FFE, much attention across the literature has been given to understanding influences within this context on children's eating behaviours and obesity status. Literature related to FFE influences on children's eating behaviours and obesity status has been reviewed in the following section to provide an overview of both interpersonal and micro-environment influences, as conceptualise to comprise the FFE. Gaps within this literature as they highlight opportunities for future research have also been discussed.

2.3.1 Interpersonal level

Within the interpersonal level of the socio-ecological model it is understood that primary social interactions occur and social and cultural norms operate. [12] From this level it is understood that a child's risk of obesity and obesogenic eating behaviours is influenced through interactions with their parents' and the socio-cultural constructs of the FFE, such as the frequency of family meals, meal structure and routine, use of TV and electronic devices, family structure including parental role modelling and levels of stress, depression and anxiety, parent's feeding strategies and parenting style, and parent's nutrition knowledge and nutrition-related beliefs. [12, 65, 204] These aspects of the FFE have been discussed in turn, prior to discussion of the microenvironment aspects of the FFE. Given the socio-demographic focus of the literature in review, generalizability is of importance and as such studies conducted within Australia have been given particular attention.

2.3.1.1 Frequent family meals

Shared family meals are often considered the core of the FFE, as a time and place that food values, beliefs, customs and traditions are centralised. Consequently, the frequency of meals shared by a family is likely pivotal in the establishment of eating behaviours and consequently obesity status. Consistent with this perspective, a systematic review of 15 studies from multiple countries (US (n=9), Canada (n=3), New Zealand (n=1), Korea (n=1), Japan (n=1)), capturing 74,080 participants aged 4 - 18 years, showed a statistically significant inverse associations between the frequency of family meals and being overweight (OR ranging from 0.11 – 0.93). [65] This seemingly 'protective' effect of family meals is further supported by the findings of a meta-analytic review that included 17 studies (participants n=182,836), focusing on children 2.8 - 17.3 years from across multiple countries (United States (n= 12), Australia (n =1), Canada (n = 1) Finland, (n =1), Japan (n =1), and New Zealand (n=1)). [205] This study specifically found that eating 3 or more family meals together per week reduced the odds for overweight by 12% (OR 0.88, 95% CI: 0.81–0.97), eating unhealthy foods by 20% (OR 0.80, 95% CI: 0.68–0.95), and increased the odds for eating healthy foods by 24% (1.24, 95% CI: 1.13–1.37). [205]

Whilst food selection is an important aspect of energy equilibrium and overall health, it has further been suggested that families who sit down together for meals are more likely to function cohesively and have more predictable routines which may also play a contributing role in the positive weight outcomes related to frequent family meals. [20, 205] In this regard, frequent family meals may serve as a marker for other aspects of family life which are similarly understood to be associated with reduced rates of obesity. [146] This prospect is, however, somewhat in contrast to the findings of a study of 560 Australian children, 5 – 6 years of age, in which families of greater socio-economic ‘advantage’ (as based on maternal education), reported eating fewer family meals together ‘four or more times per week’, as would confer an obesity promoting effect based on the fore mentioned systematic review findings. [205, 206] While this theoretical increased risk of obesity with increasing socio-economic advantage, as based on fewer family meals, is in contrast to what might be expected given the known association between socio-economic status and obesity, these findings are consistent with those reported in an online cross-sectional study of 992 Australian parents of children, 6 months to 6 years, which similarly showed greater frequency of having all family members present at evening meals to be inversely associated with socio-economic position (OR 0.70, CI 0.54-0.92). [207] Despite this, in both of these studies higher socio-economic position was positively associated with perceptions of family meals as ‘important’ and a time for connectedness. [206, 207] Consistent with this, nearly half of the most educated parents, in the sample of 506 children, reported that adult work schedules impeded on families eating together, compared to just over one quarter of the least educated parents. [206]

Based on this overview, while there appears to be substantial evidence to support the relationship between frequent family meals and healthy weight status, the exact mechanism through which this occurs remains unclear. In this regard, studies which have considered the impact of frequent family meals on children’s eating behaviours, as a possible underpinning mechanism, appear largely absent from the literature. In consideration of the evidence that other lifestyle factors may also play a contributing role in the relationship between family meals and weight status, it is too likely that a cumulative effect of multiple aspects of the FFE may contribute to the benefits of frequent family meals. Similarly, it is possible that other aspects of the FFE may negate the benefits of frequent family meals. The following section gives attention to some of these concepts further through exploration of the relationship between meal time structure and child eating behaviours and weight status.

2.3.1.2 Meal time structure

Consistent with perspectives around socio-economic differences in family meal frequency, as previously discussed, it was similarly seen (among 560 children 5 – 6 years) that least educated mothers were around twice as likely to report disagreements during meals than those mothers with higher education levels. [206] This finding further disqualifies the idea that families who sit down together for meals are more likely to function cohesively, as a suggested pathway to the positive outcomes related to frequent family meals. [20, 205] Alternatively, this finding raises questions around the importance of quality meal times and meal time structure in influencing children's obesity risk.

In exploration of this, an experimental study of 60 US families (30 families in control group; children 3 – 17 years) showed that, when loud noises were introduced during a family meal (in an adjacent experimental room), children ate more cookies ($F=9.495$, $P< 0.01$) and less pizza ($F=8.892$, $P< 0.01$), compared with children who had no additional noises during the meal. [208] Further to this, families exposed to noisy meal environments spent more time in action away from the meal ($F=9.195$, $P< 0.01$), and had less positive social interactions ($F=5.329$, $P< 0.01$) than families in the control environment. [208] These findings support the idea that the quality of meal times has the potential to impact on children's dietary intake and mealtime eating behaviours. While this study should be well regarded due the experimental conditions, it should be considered that external validity may be limited due to the use of an artificially controlled food environment. Further to this, this study is limited as hunger ratings and fasting length were not controlled for prior to experimentation.

Contributing further to the idea of the importance of meal time quality or structure, an observational study of 215 American children, aged 5 – 12 years, examining mealtime structures and family routines, revealed that overweight and obesity was associated with less time engaged in meals (-4.00 minutes, $p=0.05$), less positive communication during meals (−2.33% meal minutes, $p=0.02$), less meal scheduling (−2.02 frequency, $p=0.05$), and lower levels of perceived importance and special meaning of meals (−2.37, $p=0.02$; −1.90, $p=0.059$; respectively). [20] This study concluded that mealtimes provide opportunities to 'check in,' plan activities and monitor mood while providing an opportunity to model healthy eating practices. [20] This impact of altered meal time structure has been implicitly discussed within the subsequent sections of this chapter in relation to use of TV and electronic devices during meals, general family functioning and cohesion, parental role modelling and feeding practices, parent's knowledge and beliefs related to food and nutrition, as well as a scope of micro-environment factors which are likely to cumulatively alter meal time structure and interactions.

2.3.1.3 Use of TV's and devices

In line with the importance of mealtimes for family connection, watching TV or using other electronic devices during meals (e.g. smartphones or tablets), may disrupt communication among family members, thus inhibiting the quality of the meal time interactions and, as discussed, increase the risk of obesity. [12, 209] A longitudinal study that tracked 1430 Australian children from birth to 8 years of age, highlights the general relationship between TV viewing and obesity development, by showing that each hour of television viewed per day at 6 years of age, increased the risk of overweight and obesity at 8 years by 40%. [210] While the contribution of inhibited physical activity is also likely to be a factor in this relationship, it has further been suggested that eating while watching TV interferes with attention to the body's satiety signals, while exposure to food advertisements additionally shapes food preferences and alters food cue responsivity, thus likely leading to an increased obesity risk. [12, 209] An experimental study involving children 7 – 11 years of age (n=118) demonstrated the effect of food advertising on obesity risk by showing that children who were exposed to food advertising while viewing a cartoon consumed 45% more of a given snack, compared with children who viewed a cartoon with non-food advertising. [211] Consistent with this, a cross sectional study of 417 Australian children (10 – 16 years) showed an association between increased commercial television viewing and unhealthy food score (β=0.219, $p< 0.001$), drink score (β=0.128, p=0.002) and food/drink combined score (β=0.213, $p<0.001$), with increasing commercial television viewing, after adjusting for age and socio-demographic status. [212] As discussed in section 2.2.3, some children may further be genetically vulnerable to the effects of advertising on eating behaviours, thus at heightened risk of obesity as a result of TV viewing. [126] Of concern, in this regard, a study of 560 Australian parents of children 5 – 6 years of age reported that 54.2% of parents disagreed that food advertising had an influence on their child's eating habits. [206]

On this note, a study of 992 Australian children aged 6 months - 6 years, indicated that less than half of children (36%) watched TV during meals more than once a day. [207] This finding is similar to that reported from 560 Australian children (5 – 6 years of age), which showed that one-third of families viewed the television more than four times a week while eating the evening meal, while 21.8% reported doing so 1– 3 times a week, and 44.4% reported doing so less than 2–3 times a month. [206] These findings are seemingly promising since viewing TV during meals three or more times per week has been shown to be associated with an increased obesity risk (OR 2.07, 95% CI 1.1, 3.87) in a study of Australian children 5.3 years (n=1141). [213] Interestingly it has also been indicated that viewing television while eating was desired by almost one-third of adults in the family, which, as previously suggested, may reflect parent's desire for altered mealtime structure and/or altered family functioning (as the emotional, physical and psychological activities between family members). [206, 214] Extending on this perspective, it was further found that nearly twice as many of the least educated mothers in this study reported that adults in the family wanted to view television while eating the evening meal, compared with the most educated group (40.2% vs. 20.6%; p<0.001). [206] Consistent with this, the previously discussed study of 992 children (6 months – 6 years), showed that television viewing during meals was inversely associated with socioeconomic position (OR 0.63, CI 0.54-0.72). [207] These findings somewhat suggest that TV viewing may be a proxy for other socio-demographic factors, including family functioning, that have an association with obesity and/or deviations in eating behaviours. [63] This influence of family structure and functioning on children's eating behaviours and obesity risk are discussed in section 2.3.1.4 below.

While the mechanism underpinning the relationship between TV viewing and altered eating behaviours is likely to be multifaceted, it seems clear that TV is an important element of the FFE that is likely to play a role in obesity development. Although the effects of other handheld electronic devices (e.g. mobile phones, tablets) on childhood obesity risk are expected to be similar to those reported with TV, little research has been conducted in this area and as such it remains unclear if other electronic devices have a differing relationship with eating behaviours, meal structure, family functioning, and ultimately childhood obesity. [12] As preliminary evidence, an experimental study involving 62 Brazilian adults (18 – 28 years), who participated in snack tests on four different days showed that participants distracted by smart phones while eating consumed significantly more energy than participants who weren't distracted (591±203 kcal verse 535±164 kcal, respectively; p=0.05). [215] While not specifically involving children, these finding suggest the impact of device use during meals could similarly result in excess energy intake in children due to distraction from satiety signals, or device use by parents during meals could result in role modelling of excess energy intake (parental role modelling is discussed in section 2.3.1.5).

Further to these potential mechanisms, electronic device use during meals has the potential to impact on the emotional climate of meals, as seen in an observational study of 55 caregivers of American children (appearing to be of school age) in a fast food restaurant, where it was reported that caregivers who were highly absorbed in devices (determined based on frequency, duration, and modality of device use) responded more harshly to child misbehaviours, while children responded to parent use of devices with various behaviours including escalating bids for attention. [216] Similarly, a systematic review (n= 27 studies) into the impact of parent device use on parent-children interactions more generally indicated that device use can distract parents from interactions with their child, reduce parent's sensitivity and responsiveness to their child, contribute to family conflict, and increase child participation in attention seeking behaviours. [217] While it appears logical for these impacts of parent device use to translate to alterations in meal time behaviour and interactions, as well as altered eating behaviours, greater research in this area is needed to understand this new era of technology-based influences on children.

2.3.1.4 Family functioning and structure

As highlighted in the previous section, family functioning is likely an important aspect of the FFE, that is inter-related with many variables that contribute to obesity risk. Family functioning refers to emotional, physical and psychological activities between family members, and often includes measures aiming to capture poor communication, poor behaviour control, high levels of family conflict and low family hierarchy values. [214, 218]

A systematic review of the evidence for a relationship between child overweight and obesity (age 4 -17 years) and family functioning (measured using 13 different survey tools) specifically showed that of the 17 cross-sectional and longitudinal studies included, 12 reported significant associations between family functioning and childhood obesity. [218] Further to this, 2 out of 4 experimental studies included in this review (ranging in duration from 3 to 18 months) showed significant relationship between improved family functioning (such as improved expressiveness, chaos, and family adaptability) and positive changes in child weight. [218] One Australian study was included in this review, which showed that in multilevel model analysis, using cross-sectional data of 329 children (aged 6 – 13 years), maternal BMI and family structure (single-parent family) were significant predictors of child

BMIz (B=0.06, $p< 0.01$ and B=0.56, $p< 0.05$, respectively), however, other measures of family functioning (poor communication, inadequate support towards other family members, poor problem-solving skills, and inappropriate parenting) were not significant. [219]

In a separate study, data from Australian children 5 – 14 years of age, similarly indicated that children living in 2-parent families were less likely to be overweight or obese than those living in single-parent families (24% compared with 35%; 2011 – 2012). [19] Further to this, children from single-child households have been reported to be at increased risk of overweight and obesity in comparison to those with siblings (OR 1·52, 95% CI 1·34, 1·72). [220] Specifically, a study of 2520 Australian children (6 and 11 years of age) showed that children in dual-parent homes, those with siblings, and those with higher educated mothers and fathers, had lower BMIz (β=-0.16, p=0.002, β=-0.18, p=0.003, β=-0.12, p<0.001, respectively). [221]

Although the children included in these studies were outside of the age group in focus for this thesis, these results are consistent with those previously reported by Dubios and colleagues (2007), in their longitudinal study of Canadian children (at 2.5, 3.5 and 4.5 years), wherein 'overeating' was related to single-parent status, as well as lower family income, income insufficiency, and having overweight or obese parents, as has been discussed. [63] Consistent with this, a study of 4602 caregivers of children 1 – 12 years of age, as part of the Victorian Child Health and Wellbeing study, showed that lower caregiver education, living in a single-parent household, poorer family functioning, and parental psychological distress, were associated with poorer eating habits (consumption of potato chips, take away foods and sweetened beverages). [214]

While this relationship between poor family functioning and obesogenic eating behaviours (and poor diet quality) appears consistent with understanding of neuro-biological 'stress' related pathways to 'overeating' discussed in section 2.2.3, few studies have examined the relationship between family functioning and eating behaviours. [13, 91, 97-107] While such neuro-biological pathways seem a plausible mechanism through which poor family functioning could influence child weight, the relationship with other environmental factors also needs to be considered. For instance, it is also likely that poorer family functioning is related to aspects of low SES, as has been implicated in the literature reviewed above (e.g. low parental education, income insufficiency, lower family income) and discussed in relation to meal time structure. [63, 206, 221] Similarly to mealtime structure and frequency, other aspects of the FFE are likely to interact with family functioning in additional ways that cumulatively contribute to obesity development. Parental role modelling, parent feeding strategies and parenting dimensions are some such likely FFE factors that are also influenced by poorer family functioning and structure, as discussed in the following sections.

2.3.1.5 Parent role modelling

Role modelling is understood as an innate part of how young children learn. [222-225] For children living within homes with poorer family functioning, it is likely that they experience parental role modelling that is counter-productive to the development of healthful eating behaviours which may put them at an increased risk of obesity. For instance, parents who are experiencing emotional disfunction, as likely inter-related with poorer family functioning, may exhibit emotional eating behaviours (emotional over eating or emotional under eating) that are then acquired by children through role modelling and observational learning. [226, 227] This influence of observational learning and role modelling, on emotional eating can be seen in a study of Australian mothers with young children (2 years of age, n=306), which showed high levels of maternal depression (33%), anxiety (75%) and moderate levels of stress (45%), were positively correlated with emotional eating in both mother and child. [228] A study using data from the Gemini Twin Study (n= 2054) of British children 5 years of age, similarly showed that in a bivariate twin model, variations in both emotional undereating and emotional overeating were explained almost exclusively by shared environments (emotional overeating: C = 90%, 95% CI: 89%-92%; emotional undereating: C = 91%, 95% CI: 90%-92%). [194] These results indicate that emotional overeating and emotional undereating behaviours are learnt rather than inherited, with parents acting as a key factor in this learning process either directly through role modelled behaviours or through other facilitation of food cue associations developed within the FFE. For instance, it has been reported that among 374 Australian parents of children 1 – 3 years of age, 28% of mothers report at least sometimes offering food when their child is bored and 39% offer food when their child is crying or upset. [229] An experimental study of 25 mother–child dyads (3 – 5 years) further demonstrated the impact of feeding strategies on child emotional eating by showing that, under satiated conditions, in both the experimental (negative mood condition) and control conditions, children whose mothers often used food to regulate emotions (as measured by questionnaire) ate more cookies in the absence of hunger than did children whose mothers used this feeding practice infrequently. [230] The pattern was reversed for children of mothers who did not tend to use food for emotion regulation. There were no significant effects of maternal use of restriction, pressure to eat, and use of foods as a reward on children's snack food consumption. Further details about the impact of parent's feeding strategies are discussed in section 2.3.1.8, as are the specific roles of mothers in section 2.3.1.6.

While the genetic contribution of other eating behaviours in children is generally considered to be substantially greater than that seen for emotional eating (e.g. food responsiveness 59% hereditable, satiety responsiveness 72% hereditable [113, 195]), a longitudinal study of 156 Australian children (2 – 4 years of age) found that modelling of healthy eating by parents, measured using a study specific construct (α .70), predicted lower child food fussiness ($r=-0.27$, $p<0.01$) and less responsive eating behaviours (as associated with overeating; $r=-0.16$, $p<0.05$) after 12 months, however, no association was found in the short term with child weight status. [222] While few other studies have explicitly examined parental role modelling on children's eating behaviours, studies have examined parent and child intake of fruit and vegetables, as likely to reflect some level of parent role modelling. For instance, in a study of 564 British children 2 – 6 years of age the strongest predictor of children's vegetable and fruit consumption was parent consumption ($r=0.49$; $p<0.001$ and $r=0.39$; $p<0.001$, respectively). [224] The author of this study concluded that these findings could be attributed to a combination of factors including modelling effects, availability in the home, and other aspects of the shared environment, as well as genes. [224] On this note, in a further study of Australian children 3 – 5 years of age (n=30), positive associations were seen between children's fruit and vegetable consumption and parental fruit and vegetable intake ($B=0.30$, $p=0.005$), fruit and vegetable availability ($B=0.12$, $p=0.006$) and accessibility ($B=0.90$, $p=0.012$), the number of occasions each day that parents provided their child with fruit and vegetables ($B=1.80$, $p<0.001$), and allowing children to eat only at set meal times *all* or *most of the time* ($B=1.0$, $p=0.006$). [231] Whilst not exclusively aspects of parental role modelling, these combined characteristics of the FFE accounted for 48% of the variation in the child's fruit and vegetable score. [231]

Although there is a lack of evidence to directly link the effects of role modelling with obesity status and risk, Campbell, et al., (2008), a leading Australian researcher in the Infant Feeding Activity and Nutrition Trial (INFANT), explains that parent modelling, as one part of the FFE, is a logical focus for child obesity prevention initiatives. [65] Parents are said to have the capacity via their nutrition knowledge (section 2.3.1.10), parenting style (section 2.3.1.8 and 2.3.1.9), modelling, and the food environment (encompassing family functioning) to impact on children's emerging food choices and eating behaviours. [65] The following sections further explore the specific roles of mothers and fathers within the FFE in impacting children's eating behaviours and obesity status.

2.3.1.6 Mother's role

Maternal influence on children's eating behaviours and obesity status through the FFE have received much attention in the literature. This is, in part, because despite the increasing role of mothers in the work force over the past 30 years, mothers still assume the majority of care for children during early childhood, form the majority of single parent households, and perceive themselves as having greater responsibility over child feeding. [231-235] Within one study, 74% of mothers (n=346) specifically reported themselves as having primary responsibility over what their child eats, while the majority of other studies simply recruited mothers as the primary caregivers. [222, 231, 233, 236-239] This responsibility as the primary caregiver of children during early childhood carries with it implications for childhood obesity, with a study of 143 mothers and 68 fathers, representing 148 American children, aged 3 – 5 years, showing that mothers BMI was related to the daughters BMI ($r=0.24$, $p<0.05$) and sons fat percentage and BMI ($r=0.29$, $p<0.01$ and $r=0.4$, $p<0.001$, respectively; measured via DXA), however, no relationship was found between fathers BMI and children's weight status. [199] Interestingly, an inverse relationship was discovered between daughters BMI and fathers years of education ($r=-0.28$, $p< 0.05$) which remained significant after controlling for mothers' BMI ($r=-0.34$, $p< 0.05$). [199] On this note, although the significance of mothers and fathers in shaping children's obesity risk appears to differ, a sub-analysis of parent couples (n=68) showed that parents scored similarly on elements of the FFE that are likely to influence children's eating behaviours, such as level of control exerted over children's eating ($r=0.31$, $p<0.05$), how they perceived their child's eating risk ($r=0.50$, $p<0.001$), and their own restrictive eating behaviours ($r=0.31$, $p<0.05$), as discussed to exert influence on children via role modelling. [199] Further details regarding father's role in the FFE and parent's feeding strategies are discussed in section 2.3.1.7 and 2.3.1.8, respectively.

With mothers playing a central role in the FFE, they are likely to elicit their influence on children's eating behaviours and weight status through multiple environmental constructs and as key gatekeepers of the FFE. For instance, maternal emotional disfunction has been suggested to influence children's eating behaviours, as likely obesity intermediaries, via family functioning and role modelling, as discussed. [230] It is also likely that maternal emotional disfunction influences children's eating behaviours and obesity status via parenting style and feeding strategies, as suggested through a study of 176 American mothers of children 6 years of age, which specifically implicated the role of maternal depression in this relationship. [240] These aspects of the FFE, as largely regulated by mothers and as they influence children's eating behaviours and obesity status, are subsequently discussed following exploration of the role of fathers.

2.3.1.7 Father's role

Although mothers report having greater responsibility over child feeding and rearing in early childhood, fathers are still seen to play a significant role. Within a sample of 436 Australian fathers, 42% perceived that they were responsible at least half of the time for feeding their child, 50% for the amount of food offered, and 60% for deciding if their child eats the 'right kind of foods'. [241] Fathers within this study indicated that time spent in paid employment was inversely associated with how frequently they ate meals with their child ($\beta=-0.23$, $p<0.001$); however, both higher perceived responsibility for child feeding ($\beta=0.16$, $p<0.004$) and a more involved and positive attitude toward their role as a father ($\beta=0.20$, $p<0.001$) were positively related to how often they ate meals with their child. [241, 242] These attributes of fathers, as enacted as parental dimensions of warmth, control and irritability, as well as parenting styles (authoritative, authoritarian, permissive, and disengaged; as discussed in section 2.3.1.9) were able to explain variances in child weight status, among 4983 Australian children aged 4 – 5 years. [239] After adjustment for covariates and for the 3 paternal parenting dimensions (warmth, control and irritability, see description in section 2.3.1.9 below), the odds of a child being in a heavier BMI category decreased by 26% (95% CI: 15%–35%) for each point increase in paternal control score ($p<0.001$). [239] After adjustment for covariates, strong evidence was also found for an association between paternal parenting style and child BMI category ($p=0.002$), in that, compared with authoritative fathers, the odds of a child being in a heavier BMI category increased by 59% (95% CI: 25%–103%) for those with permissive fathers and by 35% (95% CI: 2%–80%) for those with disengaged fathers. [239]

Despite such significant contributions of fathers in childhood obesity development, fathers remain largely underrepresented in child feeding research. [188] The literature seems clear that fathers, alongside mothers, play a role in obesity in early childhood; what seems less clear is the significance of the role of fathers in obesity occurrence and the exact mechanism by which this relationship occurs.

2.3.1.8 Feeding strategies and practices

Feeding strategies and practices refer to techniques, tactics and approaches implemented by parents in the feeding of children. These strategies and practices can include restriction, monitoring, pressure, coercion, bribes and rewards, as commonly measured using the Feeding Practice and Structure Questionnaire (FPSQ/ FPSQ-28) and the Child Feeding Questionnaire (CFQ). [243-245] Parent's feeding strategies and practices are often implemented with the intention of controlling what and/or how much a child eats, and in this regard, make a significant contribution to the FFE of children during early childhood. [199, 222, 246] For example, a study of 396 Australian parents of children 3 – 5 years of age, indicated that 59% of parents restrict dessert 'most' or 'all of the time' when their child did not eat their dinner, while 29% also implemented coercive strategies by rewarding their child with dessert for finishing dinner. [231] While the intention of parents in implementing these strategies and practices is generally considered to be to positively influence children's eating behaviours, dietary intake and/or weight, parent's efforts may be counter-productive and inadvertently promote energy disequilibrium. [165, 188, 199, 243, 246-251] According to Daniels, et al., (2009), parents in general seem to fail to recognize food refusal as a sign of satiety and further condition children to ignore satiety signals through inappropriate feeding strategies and practices. [246, 250, 252]

Feeding strategies and practices that have the potential to undermine a child's hunger and satiety cues are termed 'non-responsive' and have shown a relationship with childhood obesity, as reported in a 2011 systematic review involving a total of 31 studies, 20 of which specifically focused on children during early childhood. [253] A 2015 systematic review of studies involving children, 4 – 12 years of age, specifically reported noteworthy relationships between parent's use of pressure to eat and restrictive feeding practices with child BMI. [249] Of the 21 studies included in this systematic review, pressure to eat was associated with lower child BMI in 11 cross-sectional studies, 1 longitudinal study and 1 RCT, while restrictive feeding practices were association with increases in child BMI in 14 studies, while 2 had mixed findings, 4 showed no association, and 1 showed a negative association in younger children (5 – 6 years), but not in older children (10 – 12 years). [249] This later study is of particular interest to this thesis as it involved an Australian sample (n=204, 5 – 6 years; n=188, 10 – 12 years), and specifically showed that feeding restriction scores at baseline (3 years of age; measured using the CFQ), were a significant negative predictor of child BMIz at 5 – 6 years of age (β=-0.014, 95% CI -0.024; -0.004, p=0.008), but not 10 – 12 years of age (β= -0.002, 95% CI -0.017; 0.014, p=0.815). [252] These results were largely unaffected by adjustment for child sex, maternal BMI and maternal education. [252] The authors of this study deemed this negative association between parent feeding restriction and BMIz to be clinically significant and suggested these results to reflect a *protective* effect of restriction against unhealthy weight gain in younger, but not older, children. [252]

While this study adds an interesting element in understanding the relationship between restrictive feeding practices and child weight, it is possible that parents implement different kinds of restriction (as discussed below) in older children than younger children and consequently this may have a differing impact on child weight status. Alternatively, older children may respond differently to restrictive feeding practices than younger children. In interpreting these results, however, it is also important to remember that the findings of this study were inconsistent with the results of many other studies reported across literature. For instance, Dev, et al., (2013) reported in a cross-sectional sample of 329 American parent-child dyads, that children (2 – 5 years) of parents that used restrictive feeding practices (measured using the CFQ, i.e. 'I intentionally keep some foods out of my child's reach') were 1.75 times more likely to be overweight/obese (95% CI: 1.06–2.9). [254] While the cross-sectional nature of this study limits interpretation, parents use of restrictive feeding practices were one of three variables, out of 22 ecological variables entered into a regression model, that showed association with child overweight/obesity (alongside child night time sleep duration and parent BMI). [254] Jansen and colleagues (2014), similarly reported a positive relationship between parental restriction (measured using the CFQ) and child BMI in a longitudinal study of 4166 children from the Netherlands. [255] The results of this study showed that a higher BMI at 2 years of age predicted higher levels of parental restriction at 4 years of age (adjusted β=0.07; 95% CI: 0.04, 0.10), as well as lower levels of pressure to eat (adjusted β=−0.20; 95% CI: −0.23, −0.17). [255] Derks, et al., (2017) additionally showed that within the same cohort (n=4689), higher child sex- and age-adjusted BMIz at 4 years of age predicted more restrictive feeding at age 10 years of age (B=0.15, [95%CI 0.11, 0.18], p<0.01). [256] Additionally both sex- and age-adjusted fat mass index standard deviation scores and sex-and age-adjusted free fat mass index standard deviation scores at 6 years of age were also positively associated with restrictive feeding at 10 years of age (B=0.25, [95% CI 0.22, 0.29], p<0.01 and B=0.13 [95% CI 0.10, 0.16], p <0.01). [256] Of further interest in this study, maternal concern regarding child weight partially mediated these associations from child body composition to restrictive feeding. [256]

Elucidating the direction of the relationship between parental feeding practices and child weight, as this study has, is further an important consideration in unpacking these relationships. While it is generally considered across the literature that a bi-directional relationship between parent feeding practices and child weight exists, Jansen and colleagues (2014), specifically reported that the relationship between child BMI and both restrictive feeding and pressure to eat, were stronger as child-driven associations (e.g. child BMI/eating behaviours precedes parents' feeding strategy), than as parent-driven associations (e.g. parent feeding strategies precedes child BMI/eating behaviours) (Wald's test for comparison = 5.0, p=0.03 and = 53.3, p< 0.001, respectively). [255] This tendency for parents to implement feeding practices in response to child eating temperament has been reported in multiple studies. [113, 195, 201, 249, 252, 255] Payne, et al., (2011), specifically reported that, in a study of 70 mother-father pairs with two biological children (6 – 12 years of age), concern for child weight, but not their actual BMI percentile, predicted restrictive feeding practices (measured using the CFQ) for both parents. [200] Payne, et al., (2011), suggests that within families, parents may have different interactions with each sibling regarding food (possibly through children's eating behaviours) when differentially concerned about sibling weight status. [200] Consistent with this, Harris, et al., (2016), reported that within twin pairs (n= 2026), mothers used less pressure to eat and more restrictive feeding practices (β=-0.347, p<0.001 and β=0.153, p<0.001, respectively), with the twin with higher body weight at 16 months of age. [201] Harris, et al., (2016), also reported that mothers used more pressure to eat and instrumental feeding strategies (β=0.338, p<0.001 and β=0.146, p<0.001, respectively), but not restriction, in the twin they perceived to be fussier. [201] Tripicchio, et al., (2014), similarly reported that in 64 same-gender twin pairs (4–7 years of age), mothers used more restrictive feeding practices (measured using the CFQ) with the heavier twin (r=0.31, p=0.014) and the twin with poorer caloric compensation (r=20.27, p=0.034). [202] Similarly, mothers in this study used significantly less pressure to eat with the lighter twin (BMIz, r=20.40, p= 0.001; body fat, % r=20.38, p=0.009; waist circumference, r=20.40, p=0.004). [202] These findings are indicative of child-driven associations between these variables (child weight/eating behaviours → parent feeding practices) and reflective of non-shared elements of the FFE.

Somewhat conversely, a longitudinal study of 57 American families showed greater parental restriction at 5 years of age, measured also using the CFQ, was associated in a parent-driven direction with increases in child BMIz at 7 years of age (β=0.39, $p \leq 0.05$). [257] This relation, however, was only seen among mothers who were overweight pre-pregnancy, with the authors suggesting that restrictive feeding practices may interact with a child's genetic predisposition towards obesity. [257] This perspective seems supported by a study which showed the FTO genotype to moderated the relation between parent's restrictive feeding practices and child BMI percentile (p=0.02) and BMIz (p=0.02; n=178, aged 9 – 10 years), as consistent with the behavioural susceptibility theory. [258] In this study, a one-point increase in parental restriction was associated with a 14.7 increase in the child's BMI percentile or a 0.56-point increase in the child's BMIz among children with the FTO genotype. [258]

Similar parent-driven associations between children's eating behaviours and restrictive feeding practices (measured using the FPSQ) have been partially seen in longitudinal analysis of data from the Australian NOURISH RCT collected at 2, 3.7 and 5 years of age (n=207). [259] Specifically, this study showed lower scores on covert restriction (defined as controlling a child's food intake in a way that cannot be detected by the child, i.e. 'How often do you avoid buying biscuits and cakes and bringing them into the house?' [260]) at 2 years of age was associated with higher food responsiveness at 3.7 years (β = -0.14, p=0.008), while higher satiety responsiveness at 3.7 years was positively associated with covert (β=0.14, p=0.010) and overt restriction (β=0.11, p=0.022; defined as 'controlling a child's food intake in a way that can be detected by the child' i.e. 'I intentionally keep some foods out of my child's reach.' [260]) at 5 years, in a child-driven direction, controlling for child BMIz. [259] This distinction between covert and overt restrictive feeding practices is an important feature of this study that may assist to explain some of the inconsistencies in results noted between studies that utilised the CFQ.

On this note, confirmatory factor analysis has been used to show that covert and overt restriction, as captured in the FPSQ, are conceptually and statistically separate from measures of the control feeding practices captures in the CFQ, with a maximum of 21% shared variance explained. [260] Ogden and colleagues (2006) specifically explored the distinction between overt and covert restriction in relation to child (n=297, 4 – 11 years; England) snacking behaviour to show that in response to questions regarding children's snack food intake (7 'unhealthy' items and 5 healthy items), unhealthy snacking behaviour was associated with covert restriction (B=-0.36, p=0.000) but not by overt restriction (B=0.03, p=0.6); while child's healthy snacking behaviour was associated with overt restriction (B=0.19, p=0.001) but not by covert restriction (B=0.08, p=0.2). [260] These results suggest that whilst greater covert restriction was associated with intake of fewer unhealthy snacks, greater overt restriction was associated with the intake of more healthy snacks, although the direction of these relationships cannot be assumed due to the cross-sectional nature of the study. [260] Further to this, this study showed that use of covert restriction was associated with lower parental BMI and positively associated with those that perceive their child to be of higher body weight (B=-0.24, p=0.000 and B=0.2, p=0.002, respectively; child's sex, age, social class and ethnic group were not associated), while only social class (B=0.19, p=0.008) was significantly associated with overt restriction (parental BMI, child's sex, child's age, ethnic group, and child's perceived size were not associated). [260]

Further to the benefit of the FPSQ in capturing both overt and covert restriction, the FPSQ has been seen to be appropriate for comparing the parental feeding practices of mothers and fathers. [261] That is, a cross-sectional study of Australian mothers (n = 279) and fathers (n = 225) of children 2 – 5 years of age, used confirmatory factor analysis to show that parental measures of feeding practices on the FPSQ-28 were interpreted equivalently by parents of both genders. [261] Conversely to the similarities in feeding practices noted between parents in section 2.1.3.7, this study also found that mothers implemented more covert restriction than fathers (p<0.001). [199, 261] Based on this finding it was suggest that mothers may be in a more discernible position to make food choices for children compared to fathers, since covert restriction is theorised to appropriately guide a child's eating through structure and limits, while overt restriction has been seen to increase preoccupation with the food (as discussed below). [260-262] The relationship between overt and covert restriction, children’s eating behaviours and weight status in Australian children during early childhood is, however, significantly under-represented with many of the available studies conducted in Australia utilising the CFQ or the Comprehensive Feeding Practice Questionnaire (CFPQ, see table 3). [243-245, 263] This dominance of the CFQ and CFPQ in the literature is likely to be largely explained by the fact that the FPSQ was validated in 2014, while the CFQ and the CFPQ were established in 2001 and 2007 respectively. [243-245, 263] Core constructs of the CFQ, the CFPQ, and Ogden’s, et al., (2006), constructs of overt and covert restriction, as well as several other child feeding measures were, however, used to develop the FPSQ, thus this survey measure is considered to capture critical elements of child feeding particularly relating to responsive feeding practices, as well as uniquely capturing both overt and covert restriction, as mentioned. [243] As can be seen in table 3 below, the majority of the most recent studies that have examined parent's feeding strategies have utilised the FPSQ, thus emerging research is beginning to increasingly focus on the distinctive roles of overt and covert restriction.

Although not explicitly seen in the results of the previously mentioned studies relating to covert restriction, overt restriction and children's eating behaviours [259, 260], overt restriction can also explicitly be seen in experimental feeding studies to increase preoccupation with food. [248] In a quasi-experimental study of 31 children (3 - 5 years), wherein eating behaviours towards a snack food were examined before, during, and after 5 weeks of overt restriction, it was seen that restriction to the target food significantly increased children's behavioural response to the food relative to the control food. [248] That is, relative to a similar food that was freely available during the experimental period, the restricted food elicited more positive comments, was requested more, and had more attempts from children to obtain it ($p< 0.01$). [248] This increased response relative to the control food was greater for boys than for girls during restriction (time × food type × child sex, $p<0.05$). [248] This difference in response was not, however, observed before or after the restricted access period. [248] These experimental results further reflect the potential implications of parent-driven associations and highlights potential targets for modification of children's eating behaviours and consequently obesity risk.

On this point, despite the wealth of literature supporting the presence of an inter-relationship between parent's feeding practices, children's eating behaviours and child BMI, as reviewed, Ventura, et al., (2008), concluded that studies with appropriate mediational design are lacking. [264] Joyce and colleagues (2009), provide one of the few studies that has explicitly examined a mediator relationship between parent feeding restriction, child disinhibited eating (a composite of food responsiveness and emotional eating sub-scales from the CEBQ) and child weight (4 – 8 years; n=230). [265] While the results of this study indicated children's disinhibited eating partially mediated the association between parent restriction and child BMI, the effect of this relationship was considered small and only marginally significant (CI close to 0; CI .000–.199). [265] One explanation for this result could be due to a lack of distinction between the use of overt or covert restriction, as has previously been discussed. Further to this, consideration to the context under which parents implement such feeding strategies and practices, as discussed in relation to maternal emotional disfunction and other FFE factors in section 2.3.1.6, may provide additional clarity of this inter-relationship. [240]

2.3.1.9 Parent style and dimensions

In addition to feeding strategies and practices, parents interact with their child's eating behaviours through the parenting styles and parenting dimensions implemented. Much like parent's feeding practices and strategies, parent's feeding style is likely to be inter-related with other aspects of the FFE.

Parenting style is commonly categorized into four styles; authoritative, authoritarian, permissive and neglectful/ uninvolved, each characterised by high or low demandingness and responsiveness. [266] Demandingness refers to the assertions parents make on children within the family unit by their maturity demands, supervision, and disciplinary efforts. [267] While responsiveness, or child-centeredness, refers to establishing routines and structure around eating and facilitating children's autonomy and self-regulation of food and energy intake. [188, 267] In this regard, responsive parenting reflects reciprocity between child and caregiver, conceptualized as a 4-step mutually responsive process: 1) the caregiver creates a routine, structure, expectations, and emotional context that promote interaction; 2) the child responds and signals to the caregiver; 3) the caregiver responds promptly in a manner that is emotionally supportive, contingent, and developmentally appropriate; and 4) the child experiences predictable responses. [268] These responsive parenting practices are said to be captured in the FPSQ, as aspects of authoritative parenting. [269]

Authoritative parenting (characterised by high demands and high responsiveness) has shown negative association with child obesity status, while authoritarian parenting styles (characterised by high demands and low responsiveness) has shown positive association with obesity status. [238, 239, 266] These relationships between authoritative and authoritarian parenting styles and child obesity status have been specifically seen in a study using cross-scetional data from the National Longitudinal Survey of Children and Youth study, a nationally representative survey of Canadian youth, collected between 1994 and 2008. [270] In this study of 19,026 of children 2 – 5 years of age and 18,551 children 6 – 11 years, it was found that, in multivariable analyses, preschool- and school-age children with authoritarian parents were 35% (95% CI: 1.2–1.5) and 41% (CI: 1.1–1.8) more likely to be obese, respectively, compared to authoritative parenting. [270] In preschool children, it was further found that poverty moderated this association such that authoritarian and negligent parenting was associated with 44% (CI: 1.3–1.7) and 26% (CI: 1.1–1.4) increased likelihood of obesity, respectively, but only among the children not living in poverty. [270] In school-age children, poverty was not a moderator. [270] This moderating effect of SES was also found in a study of 176 mothers of children 5 – 6 years of age, which showed both maternal depression and SES moderated the effect of permissive parenting style on child obesity status, but not the effect of authoritarian parenting on child obesity status. [240] That is, for depressed mothers, more permissive parenting increased the odds of obesity by 6.74 (95% CI 0.96, 47.16, $p=0.05$), however, this relationship was not seen in non-depressed mothers. [240] Similarly, more permissive parenting was predictive of child obesity among higher SES mothers (OR 3.15; 95% CI 0.99, 12.39, $p=0.05$), but not for lower SES mothers. [240] These findings again serve to highlight the interaction of environmental circumstances on obesity status, although the role of eating behaviours in such relationships has not been examined specifically. Further details regarding the impact of SES on childhood obesity are discussed in section 2.3.2.3.

Further to parenting style, parenting dimensions have been used to conceptualise responsive parenting practices, as referred to as parental warmth (affectionate interactions that are responsive to children's needs), control (firm discipline in terms of the setting of developmentally appropriate limits and expectations for children's behaviour; not to be confused with control feeding strategies) and irritability (irritable, angry affect) - as have similarly been seen to be associated with child weight status. [239] For instance, in a study of 4983 Australian children 4 – 5 years, after adjustment for covariates, paternal use of the control parenting dimension was associated with a decreased odds of the child being in a heavier BMI category (OR: 0.75; 95% CI: 0.65–0.86; $p<0.001$), although this was not seen for maternal use of control and no other parenting dimensions showed association with child BMI category. [239] This study further supported the role of parenting style in childhood obesity by showing children with permissive and disengaged parents had 59% (95% CI: 25%–103%) and 35% (95% CI: 2%–80%) higher odds of being in a heavier BMI category, respectively, compared with the reference, authoritative, style parenting, although, neither maternal or paternal warmth or irritability were associated with child BMI category ($p\geq0.79$). [239]

2.3.1.10 Parent's personal resources and knowledge

Further to the way parents engage in parenting their child, as through parenting styles and dimensions, a parent's personal resources, such as food procurement and preparations skills, as well as their nutrition knowledge and nutrition related beliefs, are considered critical facets in shaping the FFE. That is, a parent's personal resources can be reasoned as contributing factors in the types of foods purchased and made available within the home, to consequently influence eating behaviours and dietary intake, providing a pathway to energy disequilibrium. [237] Campbell, et al., (2013), demonstrated this in part, with the finding that nutrition knowledge mediated the intake of fruit ($B=0.03$ [95% CI: 0.01, 0.06], $p<0.001$), vegetables ($B=0.02$ [0.00, 0.03], $p<0.05$), salty snacks ($B=-0.02$ [-0.05, 0.00], $p<0.05$), and soft drink ($B=-0.03$ [-0.05, -0.01], $p<0.001$), in a study of Australian children ($n=536$, 5 – 12 years of age), via home food availability. [237] Child weight was not, however, associated with dietary intake in this study and children's eating behaviours were not assessed. [237]

This idea of an indirect effect on parent's nutrition knowledge on child weight seems supported by multiple studies across the literature since few studies show a direct relationship between parent's nutrition knowledge and child weight. [223, 237, 271-275] Hendrie and colleagues (2012), are the exception to this, however, with the finding that parent's weight ($\beta=0.34$, $p<0.005$) and nutrition knowledge ($\beta=-0.21$, $p<0.005$) had a direct relationship with child BMIz in a study of 157 Australian children 5 – 11 years. [276] This study further found that, through structural equation modelling, parent's nutrition knowledge was directly associated with general parenting style ($\beta=-0.25$, $p<0.005$) and child feeding practices ($\beta=-0.50$, $p<0.005$), which in turn was related to family physical activity ($\beta=0.63$, $p<0.005$) and the food environment ($\beta=-0.74$, $p<0.005$). [276] Parent's nutrition knowledge was also directly related to parent's own diet quality ($\beta=0.24$, $p<0.005$), which in turn had a positive relationship with the food environment ($\beta=0.24$, $p<0.005$). [276]

Further to this inter-relationship between parent's nutrition knowledge and other aspects of the FFE, an additional study by Gibson, et al., (1998), provides evidence that parent's nutrition knowledge is inter-related with parent's nutrition-related attitudes and beliefs. [271] That is, Gibson, et al., (1998), used study specific constructs to show that, in a study of 92 mother and child dyads (9 – 11 years), mother's nutrition knowledge was an independently associated with child fruit intake ($\beta=0.37$, $p=0.000$), as was mother's fruit consumption (β=0.30, p=0.004), and mother's attitude towards diet-disease risk (β=0.27, p=0.008). [271] Children's vegetable consumption was also independently explained by their liking for commonly eaten vegetables (β=0.36, p=0.008) and mother's belief in the importance of disease prevention when choosing food for her child (β=−0.27 p=0·001). [271] Lastly, children's confectionery consumption was associated with mother's liking for confectionery (β=0.32, p=0.006) and her concern for health when choosing food for her child (β=–0.26, p= 0·005). [271] Child weight and eating behaviours were also not reported in this study, however.

This work of Gibson, et al., (1998) is unique within the literature, as one of the only studies to have explored the role of parent's nutrition related beliefs in shaping aspects of the FFE. Alternatively to examination of parent's nutrition-related beliefs directly, however, of the available data reflecting the self-efficacy (one's confidence in their ability to perform a health behaviour; as inter-related with the cognitive constructs of beliefs, nutrition knowledge, confidence, and food literacy skills) of Australian parents (n=560, children aged 5 – 6 years), approximately 70% felt confident to cook a wide variety of meals, over 25% agreed that it is difficult to find time to cook the evening meal (with parents in the most educated group reporting higher on this scale), 30% reported that they plan the evening meal well in advance, and around 12% of least educated (compared with 5% of the most educated) reported their family's dislike of fruits limits their purchasing habits. [206] From these findings it is clear that parent's self-efficacy is likely to interact with aspects of the FFE such as frequency of family meals and meal time structure, as well as other personal resources of parents, to have an overall influence on child obesity risk.

A further Australian study using structural equation modelling, similarly, detected multi-directional relationships between maternal feeding self-efficacy, parenting confidence, child feeding behaviour, exposure to new foods, and fruit and vegetable intake, within a cohort of 277 children aged 6 – 24 months (mean 27 weeks). [277] While the age of the sample in this study is below that of the focus in this thesis, consideration of multiple components and multi-directional relationships is a key feature of the study that provides an important perspective in understanding the interactions of FFE variables. Unfortunately, however, child weight and/or and eating behaviours were not reported in this study, nor were a broader range of variable conceptualised within the FFE as described in this thesis to likely have a compounding effect on child weight status.

Despite nutrition related knowledge forming only one aspect of a parent's personal resources that are likely to have an impact on the FFE, understanding where parent's source nutrition information is important for public health and health promotion planning, and may further serve to highlight opportunities and avenues through which target populations can be reached. On this note, a cross-sectional study of 277 first time Australian mothers found that friends and relatives were the most common source of infant feeding information (77.6%), followed by books or videos (76.8%), and doctors or other health care providers (69.1%). [278] The internet was also reported by 72.6% of mothers as a source of breastfeeding information. [278] It was similarly reported in a study of 34 Australian mothers of children 6 months to over 2 years of age, that the internet (n = 27; 79%), friends (n = 21; 61%) and family (n = 15; 44%) were usual sources of child nutrition information. [279] This high popularity of the internet as a source of nutrition information is discussed in section 2.3.2.2 in terms of being a digital resource within the micro-environment level of the home.

2.3.2 Micro- environment level

In addition to the contribution of interpersonal level factors, the FFE is conceptualised to also comprise micro-environment variables which operate within the home by imposing structural boundaries on food and eating occasions. These aspects of the FFE are dictated by the physicality of the home (often referred to as kitchenscape, tablescape, platescape, and foodscape), household budgets, and other family resources that are out of the direct control of parents, although in accordance with the socio-ecological model, interact with interpersonal elements to shape the FFE. These aspects of the micro-environment as they contribute to the FFE, influence eating behaviours, and impact upon obesity status in early childhood have been discussed in the following section.

2.3.2.1 Physicality of the home and home resources

Eating behaviours are well understood to be influenced by physical settings and objects, as has been discussed regarding food cues that stimulate food choice and eating in response to the hedonic appetite system (section 2.2.3). [84, 184, 280] Moreover, the physical aspects of the home place boundaries on the execution of eating occasions and food procurement through structural constrains and resource limitation, thus are likely to have an influence on obesity status. For example, small kitchens with inefficient designs have been implicated as a physicality within the FFE that may impact on obesity development by discouraging the preparation and consumption of less convenient and more healthful meals. [12] This is evident in a study of 345 Australian children aged 12 – 13 years, whereby parental reports that the kitchen was poorly set up for meal preparation was inversely related to savoury snack consumption among boys (β=-0.193, p=0.012). [281] In this regard, it can be expected that inappropriate kitchen or dinning space could elicit its effect on the FFE via impact on the frequency of family meals, mealtime structure and consequently opportunity for parental role modelling, as has been discussed to have implications for weight status (section 2.3.1.1, 2.3.1.2 and 2.3.1.5). It is also likely that inappropriate kitchen or dinning space could re-enforce beliefs around the ease and convenience of cooking meals and healthful eating (section 2.3.1.10) to further impact on child obesity risk. [205, 209]

Similarly, inadequate food storage resources within the home may force families to alter food purchasing behaviour. This effect can be seen in a study of 20 key informants that reported on factors which affect food insecurity in children from regional and remote areas of Western Australia. [282] This study showed that small fridges/freezers and/or intermittently working facilities (including power outages) contribute to food insecurity through an increased need for families to shop daily or multiple times daily, and an inability to buy food in bulk, as is often more cost efficient. [282] Furthermore, it has been seen within a Melbourne case study that lack of access to a car can reduce access to food by 50%. [283] A lack of access to personal transport has similarly been noted as one of the main barriers that affected dietary choice in a study of low SES parents of infants from Wales. [280] This study additionally implicated a reliance on fast food outlets due to work schedules, an inability to cook, parents own childhood dietary experiences, peer pressure, and familial relationships, as key factors influencing dietary choices of low SES parents. [280] Although the generalisability of this study to this thesis may be limited, these findings are consistent with those discussed in relation to family structure which attributed frequency of unstructured meals to busy parents and family life, as was associated with increased child weight status. [205, 209]

As has been seen throughout this section and as explored in more detail in section 2.3.2.3 below, insufficient income and low SES interact with many elements of the FFE which may contribute to obesity status. Broader data reflecting the physicality and resources of homes, as likely important constituents of the FFE that influence children's eating behaviours and/or obesity status, are scarce. These gaps in data contribute to fragmented understanding of the FFE during early childhood and limits understanding of interactions between these variables.

2.3.2.2 Digital resources – internet and social media

The rapid emergence of the digital era has added a new dimension to home resources that has the capacity to significantly shape the FFE. While the use of TV and electronic devices has been discussed from the perspective of impact on eating behaviours and obesity status, in this section access to internet-based technologies are specifically examined as a digital resource within the home that has the capacity to enable health behaviours.

That is, access to internet-based technologies, including websites and social media platforms, enable parents to readily connect with information, services, health care professionals, as well as other parents in ways that can promote health. [279, 284] For instance, the use of the internet has the potential to compensate for transport limitations that can inhibit access to food, as previously discussed [283], by allowing people to have groceries delivered to their homes. [285] A recent study of 333 Australian adults (18 – 45 years), has indicated, however, that this service has not been readily adopted by Australians, with only 18% of respondents (across multiple states) indicating they had engaged with online grocery shopping. [285] Despite the potential underutilisation of the internet to assist with procurement of healthy foods, 97% of Australian households with children under 15 years have access to the internet, which according to data from 2016 - 2017, is predominantly used for entertainment, social networking and banking (cumulatively accounting for 80% of use). [286, 287] Further to this, the internet is used by 46% of Australians to access health services or health research (2016-2017). [287]

On this note, as of September 2016, Facebook® was Australia's most popular social media platform with 15,000,000 steady user (in comparison to Twitter®, with 2, 800, 000 users, and Instagram® with 5, 000, 000 monthly active users), accumulating 95% of social media usage, with 26% of users accessing sites such as Facebook® more than five times per day. [286] This popularity of Facebook® is slightly stronger amongst females (3% higher than males) and those under 40 years of age (75% – 66% compared with 52% - 20% amongst those over 40 years), although, distribution across metropolitan verse regional areas is fairly consistent. [286] This wide-reaching appeal and high engagement levels with Facebook® indicates this platform is a highly used digital resource of primary carers of young children in Australia.

Despite this largely equitable usage of Facebook® across regions, internet access in general is not distributed evenly across the population, with differences seen between major cities and remote or very remote areas, with 88% and 77% of residence having access, respectively. [287] Similarly, differences in internet access exist between income groups, with nearly all Australian households (97%) in the highest income quintile (2008-2009) reported to have home internet access, compared with 61% of households in the lowest income quintile. [187] While these data are dated, such disparities in digital resources are likely to contribute to inequities within the FFE, particularly in relation to a diminished digital capacity to seek health information and/or to seek social support, as in line with common uses for the internet in Australia. [280, 287]

In regards to social support, for those with internet access, the popularity of social media sites (as are used by 69% of internet users), provides an alternative and modern way to connect with friends, family and other parents. [286] These connections are an important part of parenting, and have been identified as key sources of child feeding and nutrition information for parents (section 2.3.1.10). [279] Consequently, lack of access to the internet may deprive parents of social connections that have been described to play a central role in increasing a mother's sense of empowerment, or self-efficacy, that underpins health behaviours. [279, 288, 289] Despite some inequalities in internet access as a digital resource within the FFE, the internet is a promising platform with wide reach and high usership across all demographics, through which health behaviours and social facilitation, can be enabled. Further research is needed in order to better understand the *depth* of the engagement with internet-based technologies and the potential of platforms such as social media to reach and engage parents with health promotion messages.

2.3.2.3 Household income

Household income (as often used as a proxy measure of SES) has a well-established influence on children's eating behaviours and obesity status, as exampled in section 2.2.3 in terms of 'disadvantaged' circumstances that alter neuro-biological pathways, as well as through interactions with FFE variables (parents' psychosocial wellbeing, emotional disfunction, family functioning, use of TV during meals, parent feeding strategies, parenting dimensions, and the physicality of the home), as discussed throughout this chapter. [12, 210, 280, 290-292]

To summarise what has been discussed in this regard, compared to high income families, children from low income or low SES families, are reported to have lower priority for family meals, more disagreements during meals, have parents with less authoritative parenting style - with higher use of food rewards, are less likely to have healthful foods within the home, have parents with lower concerns about child weight, are exposed to less parental role modelling of fruit and vegetable intake, watch more television, are more likely to eat while watching television, and ultimately are more likely to be overweight as children and adults. [12, 210, 280, 290-292] Specifically, those living in the most disadvantage areas in Australia are 10% more likely to be obese than other Australians. [146] Similarly, being from a family with food insecurity, as often related to income, has been seen to double the proportion of children classified as overeaters (12.5%) compared to food-sufficient families (6.2%), among 1498 Canadian children in early childhood. [63] Studies examining the impact of income status on children's eating behaviours in early childhood in Australian, and the subsequent impact on obesity and/or inter-relationship with other FFE variables, is limited. Further details of macro-level (top-down) impacts of SES are available in Appendix 3.

2.3.3 Summary and discussion of family food environments

The literature reviewed has identified variables as conceptualised within the FFE that appear to play a role in the relationship between eating behaviours and obesity status in children during early childhood (Appendix 2). Given the specific interest in Australian data, table 3 provides a summary of studies conducted in Australian children during early childhood (between 2000 – 2018) with a focus on eating behaviours, obesity status and FFE variables. In accordance with the first two components of the 4-component process in planning health interventions (figure 3), these variables within the FFE are largely considered modifiable.

While it is acknowledged that bi-directional relationships are likely to exist between many FFE variables, children's eating behaviours and obesity status, given that parents act as gatekeepers of the FFE it seems logical to focus on the potential of parent-driven associations to positively impact on children's eating behaviours and obesity risk. This potential is further based on understanding of the emergence of children's eating behaviours during early childhood (section 2.1), whereby deviations in young children's eating behaviour (e.g. increased food approach eating behaviours and/or reduced food avoidance eating behaviours, such that energy homeostasis is not maintained) appear to emerge before obesity develops. [58-60] Consequently, modifications within the FFE have the potential to reduce obesity development via changes in children's eating behaviours. In this regard, the literature reviewed indicates that enabling families to modify FFEs such that they share regular family meals, engage in quality interactions during such meals, and avoid distractions including the use of TV and electronic devices, is likely to be of benefit to children's eating behaviours and obesity risk. FFEs should further be modified such that parent's role model healthy eating behaviours, while engaging in responsive feeding practices that support children to appropriately regulate and respond to hunger and satiety signals. Although FFE elements, such as the physicality of the home (e.g. cooking and food storage facilities), may not be directly modifiable by parents, development of food utilisations skills and nutrition knowledge may support parents to modify the FFE in such a way to maximise the micro-environment resources available (e.g. making healthful food purchasing decisions based on the available financial resources and cooking facilities).

While these modifications within the FFE are largely supported by the literature, although limited due to the dominance of cross-sectional studies, most studies have examined relationships between only select FFE variables with eating behaviour and/or weight status. This focus on select FFE variables fails to draw a comprehensive picture of ecological exposures during early childhood. In interpreting the current literature this is important to consider, given that in the essence of the socio-ecological model, variables within the FFE are not operating isolation. Rather, variables within the FFE interact with each other (section 2.3), with upstream variables (Appendix 3), as well as with intrapersonal level factors (section 2.2). This limitation in the literature can be seen in table 3, with none of the Australian studies identified examining a breadth of FFE variables. Given that FFE variables do not occur in isolation, studies are needed that examine both the breadth of variables as well as the collective influence of variables within the FFE. This will allow a more thorough understanding of obesity during childhood and may serve to guide future, multicomponent interventions. Inconsistencies in conceptualisation and measurement of FFE variables further needs to be addressed, as this issue additionally limits ability to interpret relationships between variables. This issue is particularly pertinent in relations to measures of parental feeding strategies and practices, wherein more recently developed measurement tools (e.g. FPSQ) divide constructs of restriction into overt and covert, as uniquely distinct constructs. This addition to the literature has resulted in substantially new interpretations of data that requires additional research.

Further to this, understanding within this area of research is limited due to much of the evidence derived being based on analysis from a limited number of cohort samples. Data from the Gemini Twin Study of 2400 families with twins born in 2007 in the UK, for instance, has been used in at least 15 publications. [293] Similarly with evidence pertaining specifically to Australian children, data from the NOURISH RCT, the InFANT feeding trial, and Longitudinal Study of Australian Children, dominate the literature, making up evidence used in 13 out of 30 studies included in table 3 (below). This homogeneity of the samples on which current understanding is based, similarly limits understanding of the relationship between children's eating behaviours and psycho-social factors (intrapersonal determinants; section 2.2). No current data are available that explore the relationship between children's eating behaviours specifically within sub-population groups, such as children of single parents, children living in rural/regional geographic regions, or those of socio-economic diversity in Australia. The relationship between children's eating behaviours with potentially important psycho-social variables and co-variates of child weight, such as parent's BMI, parent's levels of depression, anxiety and stress, child sleep duration and/or breastfeeding duration, are also lacking (table 3). Developing understanding of the influence of these psycho-social variables may assist to explain differing rates of obesity within the population and in understanding child-driven associations between children's eating behaviours ad/or obesity status and FFE variables (section 2.2). In this regard, developing such understanding in future research could further assist in determining the capacity of children's eating behaviours to be modified within the FFE from a parent-driven perspective.

Further to this fragmented understanding of the relationship between FFE variables, children's eating behaviours and obesity status, opportunities to explore potential mediator relationships and interactions between these variables has largely been overlooked. [2] As highlighted, childhood obesity is a multifactorial condition which involves interaction between genetics, environments and behavioural responses. [55, 60, 255, 294] There is strong theoretical justification for a mediator relationship between these variables and as such, determining the presence of a mediator relationship may encourage unique and novel approaches to obesity prevention and support the use of eating behaviours as intervention endpoints.

Table 3: Summary of family food environment studies in early childhood in Australian and highlighted opportunities for future research									
Australian Early Childhood Studies	**Obesity**	**Eating Behaviours**	**Feeding Strategy/ Parent Style**	**Sub-populations***	**TV/ devices**	**Family Meals/ Meal structure**	**Food & Nut. Knowledge, values & self-efficacy**	**Home/ digital Resources**	**Psycho-social & co-variates****
Mallan, et al., (2015) [68] 14 months & 3.7 years (NOURISH RCT) n= 340	✓	✓							
Mallan, et al (2014) [60] 4.2 years (NOURISH RCT) n=37	✓	✓							
Perry, et al., (2015) [295] 2 years (NOURISH RCT) n=330	✓	✓							
Gregory, et al., (2010) [222, 251] 2 - 4 years (Child and Family Health Study in Melbourne) n= 183 (T1) n= 157 (T2)	✓	✓	✓ (CFQ)						
McPhie, et al., (2011) [296] 2 – 4 years n= 175	✓	✓	✓ (CFQ)						
Rodgers, et al., (2013) [297] 2 years n= 323	✓	✓	✓ (CFQ)						
Byrne, et al (2017) [298] 14months & 2 years (NOURISH RCT) n= 330	✓	✓	✓ (FPSQ)						
Fildes, et al., (2015) [67] 16 months or 3 - 4 years (NOURISH RCT & GEMINI [UK]) n=1211		✓							
Adamson, et al., (2015) [299] 2 - 5 years n= 96		✓	✓ (PATFA)						
Rodgers, et al., (2014) [228] 2 years n=323		✓							✓ (Maternal affect)

Chan, et al., (2011) [229] 1–3 years n=740		✓	✓ (Study specific)				✓		
Jansen, et al., (2018) [259] 2, 3.7, and 5 years (NOURISH RCT) n= 207		✓	✓ (FPSQ)						
Russel, et al., (2018) [300] 1.3 – 2 years and 4 – 6 years (InFANT feeding study) n=1326 and n= 751, respectively	✓		✓ (CFPQ)						
Taylor et al., (2011) [301] 4 – 7 years (Longitudinal Study of Australian Children) n=4423	✓		✓ (CRQ)	X					
Renzaho, et al., (2014) [214] 1 – 12 years (Victorian Child Health and Wellbeing study) n=4602				X					✓
Mallan, et al., (2013) [241] 2 – 5 years (NOURISH RCT & Griffith Study of Population Health: Environments for Healthy Living) n=436				X		✓			
Mallan, et al., (2014) [242] 2 – 5 years (NOURISH RCT & Griffith Study of Population Health: Environments for Healthy Living) n= 340			✓ (CFQ)	X					
Wake, et al., (2007) [239] 4 - 5 years (Longitudinal Study of Australian Children) n=4983	✓		✓ (CRQ)	X					
Daniels, et al., (2013) [233, 250] 4 years (NOURISH RCT) n=698	✓		✓ (CFQ)				✓		
Rodgers, et al., (2013) [302] 2years n=202	✓		✓ (CFPQ)						✓

Wyse, et al., (2011) [231] 3 - 5 years n=396			✓ (CFQ)			✓		✓	
Spurrier, et al., (2008) [303] 4.8 years n=280					✓			✓	
Wheaton, et al., (2015) [292] 4 - 5years (Longitudinal Study of Australian Children) n=4169	✓			X	✓				
Hardy et al., (2012) [213] 5.3 years (Schools Physical Activity and Nutrition Survey) n = 1141	✓				✓				
MacFarlan et al., (2009) [304] 5–6 years and 10–12 years (Health, Eating and Play Study) n=161 and n=132, respectively	✓				✓				
Litterbach, et al., (2017) [207] 6months – 6 years (Family Meals with Young Kids study) n = 992				X	✓				
Campbell et al., (2002) [206] 5 – 6 years n = 560				X	✓	✓			
Hesketh et al., (2007) [221] 6 and 11 years Children's Leisure Activities Study & Health, Eating and Play Study n= 2520	✓			X X					
Jansen, et al., (2018) [261] 2 – 5 years Mums and Dads (MAD) for Mealtimes n= 504			✓ (FPSQ)	X					
Burke, et al., (2005) [210] 16 weeks gestation – 8 years Raine cohort n= 1430	✓			X	✓				✓

*Sub populations: Single parents; fathers; rural/regional; low socio-economic status
**Psycho-social and co-variates: parent's depression, anxiety & stress; parent BMI, child sleep, breastfeeding duration
CFQ – Child Feeding Questionnaire; FPSQ – Feeding practice and Structure Questionnaire; PATFA - Parent and Toddler Feeding Assessment; CRQ - Child Rearing Questionnaire; CFPQ - Comprehensive Feeding Practices Questionnaire
Blue shading indicates studies which included measures of Children's eating behaviours

2.4 Modification of eating behaviours during early childhood

2.4.1 Rational for intervention

Given that in early childhood it appears that children's eating behaviours precede obesity development (section 2.1) [58-60], modifications of the FFE are considered to have the potential to reduce children's obesity risk via eating behaviours. While it is acknowledged that bi-directional relationships between FFE variables, children's eating behaviours and weight status likely exist, given the importance of parents as gatekeepers of the FFE, addressing influences from a parent-driven direction is a logical approach. In this regard, the FFE contains a range of variables that are likely modifiable (e.g. parent feeding practices, use of TV and devices during meals, parent's nutrition knowledge; section 2.3), and as such, good targets for intervention. [40]

The following section provides a review of the literature in relation to interventions that have attempted to modify children's eating behaviours, address childhood obesity and modify elements of the FFE. Attention has also been given to selection and justification of theoretical models for intervention development, in accordance with the third component in health intervention planning. Intervention strategy options have been also explored, as relevant to capacity building stages (figure 4).

<table>
<tr><th colspan="4">Figure 4: Thesis mapping schematic model – Chapter 2.4</th></tr>
<tr><th>4-component process [45, 46]</th><th colspan="2">Capacity building stages [50]</th><th>Thesis section 2.4 key points</th></tr>
<tr><td rowspan="2">1. Identification of modifiable factors which could be target behaviours

2. Identification of potential mediators

3. Selection and justification of theoretical</td><td rowspan="2">Assessment

Analysis</td><td rowspan="2">Define needs and analyses problem

Determinant analysis</td><td>Chapter 1: Introduction
• Childhood obesity major public health issue
• Family food environments are the central context in which early childhood obesity emerges

Chapter 2: Literature review
• Children's eating behaviours associated with child weight status
• Family food environments provide a key context in which obesity status interactions with eating behaviours
• Children's eating behaviours appear promising as obesity intervention endpoints</td></tr>
<tr><td>• Family food environments offer opportunity for intervention directed towards eating behaviours and obesity development
• The social cognitive theory (SCT) and health belief model (HBM) provide a suitable framework for intervention planning
• Technology offers new opportunity for intervention delivery</td></tr>
</table>

model			**Chapter 3: Methods** 3.1 Aims and research questions 3.2 Survey 1: Eating behaviours & family food environment 3.3 Survey 2: Intervention opportunities & acceptability **Chapter 4: Results** 4.3 Survey 1
4. *Design intervention*	**Action**	Explore strategy options	4.4 Survey 2 - Intervention opportunity & acceptability survey 4.5 Overall discussion & recommendations
	Assessment	Implement the strategy portfolio & evaluation	**Chapter 5: Future direction & conclusion** 5.3 Recommendation for intervention design 5.4 Implications for research and practice

2.4.2 Eating behaviours as a surrogate intervention endpoint

While childhood obesity is an issue of major public health concern, interventions that have successfully prevented or treated obesity in young children are limited. For instance, a recent systematic review and meta-regression (2017), including RCTs published between 1990 and 2017 that examined behavioural interventions to prevent and treat obesity among children 2 – 18 years of age, found that of 133 studies included (52 including only children 2 – 11 years of age), 56% demonstrated a statistically significant decrease in the standardized outcome (e.g. BMIz), however, 40% demonstrated no significant change, and 4% demonstrated a significant increase in the standardized outcome. [305] Although these findings appear to hold some promise in terms of interventions being effective in obesity prevention and treatment, the inclusion of children up to 18 years is likely to have contributed to the positive findings, with results in studies of younger children tending to show less positive effects on child weight status. [305] A similar systematic review of RCTs (n=7) aimed at the prevention of overweight and obesity in children less than 5 years of age, further showed no interventions to be effective in preventing overweight and obesity (prior to 2008). [306] This review specifically concluded the seemingly limited success of interventions in young children to be due to the quality of the intervention, sub-optimal implementation of intervention protocol, and/or a lack of focus on social and environmental determinants. [306] Additionally, it was suggested that the choice of outcomes measured could interfere with the success of the intervention. [306] That is, since detecting preventative differences in child weight status is likely to require an extended intervention period and/or follow up, which is often not logistically possible, an alternative intermediate outcome or ‘surrogate endpoint,’ may be a more efficient measure of intervention effect (table 4 for additional obesity prevention trials). This is a reasonable speculation given that, the average intervention duration reported in the systematic review of children less than 5 years of age [306] was 17.3 weeks, with a median of 18 contact hours, which may not be long enough to detect meaningful and sustained weight changes, particularly in children who are undergoing dramatic growth and change in body composition and/or in children who are not presently overweight. [306] Instead, children's eating behaviours may be a suitable 'surrogate endpoint' for obesity prevention interventions in early childhood, as likely obesity intermediaries.

The results from the previously mentioned NOURISH RCT, a large intervention which provided first time mothers (n=698) anticipatory guidance to support the establishment of complementary feeding practices, is among the few studies to have published data on changes in eating behaviours following an obesity prevention intervention. [233, 250, 307] Specifically, follow up data at 2 years and 3.5 years after participation in the NOURISH RCT (children up to age 5 years), showed that intervention children, compared with the control group, had altered eating behaviours. [233, 250, 307] At 2 years, intervention children were reported to have higher satiety responsiveness (3.12 v 3.01, scored out of 5 in the CEBQ sub-scale, p=0.03), lower emotional overeating (1.48 v 1.60, scored out of 5 on the CEBQ sub-scale, p=0.009) and lower food fussiness (2.46 v 2.62, scored out of 5 on the CEBQ sub-scale p=0.01). [308] At 3.5 years, intervention children were reported to have lower food responsiveness (2.3 vs 2.4, scored out of 5 on the CEBQ sub-scale, p=0.04) and higher satiety responsiveness (3.1 vs 3.0, scored out of 5 on the CEBQ, p=0.04). [307] While these changes did not reflect variations in BMI (which may take longer to detect), they were matched with other 'health promoting' outcomes such as higher preference for fruit (at 3.5 years 74.6% v 69.0%, liked, p<0.001) and higher intake of fruit and vegetables (at 3.5 years 15.3 vs 14.5, p=0.03). [307] These differences between the intervention and control groups were attributed to the intervention protocol which, through two modules of six fortnightly parent education and peer support group sessions, followed by six months of maintenance contact, saw intervention parents implement responsive feeding practices more frequently (e.g. trusting the child's appetite and interpreting food refusal as satiety), less controlling feeding practices (e.g. pressure and encouragement to eat more through coaxing, using rewards, or offering favourite foods as alternatives), and more frequent use of feeding practices likely to enhance food acceptance. [233, 250] These findings, particularly when considered alongside the cross-sectional evidence previously presented in this thesis (section 2.3), supports that affecting change within the FFE is likely an effective way to positively influence children's eating behaviours, as relevant in developing an obesity prevention intervention.

Despite this evidence which supports changes within the FFE resulting in beneficial modifications in children's eating behaviours, and thus a potential surrogate endpoint in an obesity prevention intervention, much remains unknown about this opportunity to positively influence or 'correct' children's eating behaviours. That is, while differences in eating behaviours were reported at 2 years and 3.5 years post-intervention (children up to 5 years of age) in the NOURISH RCT, it remains unclear if similar changes could be achieved in a shorter duration. [233, 250, 307] Furthermore, it remains unclear if these changes in either parent's feeding strategies or children's eating behaviours were maintained beyond follow up, or if they had a longitudinal impact on child weight status. It is also unclear if the inclusion of a broader range of FFE variables as intervention targets would have a greater (cumulative) effect on children's eating behaviours. Similarly, since the NOURISH RCT initiated anticipatory guidance when children were approximately 4 months old, it is not clear if eating behaviours at a population level are similarly malleable in older children, once they have been established and reinforced within the FFE. Likewise, it remains unknown if children who are already overweight and obese, or predisposed to deviations in eating behaviours due to genetic or psycho-social variables, would respond equally to intervention protocol. While not clinically investigated, Jansen, et al., (2018), stated in a cross-lag analysis of data from the NOURISH RCT that there appears to be only a small window of opportunity for intervention that targets parental feeding practices to modify children's eating behaviours as a mediator of obesity status. [259] This perspective was said to be consistent with child development models and life course approaches, which recognise biological and behavioural plasticity early in life that is advantageous for intervention success. [259]

On this note, as children's eating behaviours are reported to have varying levels of heritability (section 2.1), the degree to which differences in various eating behaviours can be achieved is likely to vary. For instance, as satiety responsiveness and slowness in eating appear to be predominately underpinned by genetics, while enjoyment of food and food responsiveness are explained almost equally by genetic and environmental factors [113], and emotional eating behaviours are explained almost exclusively by environmental factors [194], a greater degree of difference could be expected in the latter behaviours. This prospect is not, however, clearly evident from the results of the NOURISH RCT which achieved positive changes across a breadth of eating behaviours. In a similar regard, given that eating behaviours can be seen to be associated with weight status to varying degrees, it could also be expected that some eating behaviours would be more influential in obesity prevention than other. Satiety responsiveness, for instance, showed stronger association with child weight ($B=-0.49$, $p<0.0001$), than enjoyment of food ($B=0.25$, $p=0.003$) in a study of 406 children 7 – 12 years. [5] Additional research is needed in this regard to determine where attention in obesity prevention should be focused and provide answers to these remaining questions.

Whilst not answering such remaining questions, the Feeding Dynamic Intervention (utilising the Feeding Dynamic Model) proposed by Eneli, et al., (2015), similarly highlights the potential of eating behaviours as intervention targets. Specifically, the Feeding Dynamic Intervention focused intervention design on ‘competent eating’ outcomes in children 2 – 5 years, as conceptualised to comprise eating attitudes, food acceptance, regulation of food intake and body weight, and management of the eating context (including family meals); however as yet, results from this intervention have not been published. [309-311] While the concept of a ‘competent eater’ draws many parallels with the idea of achieving and maintaining energy homeostasis through a balance of food approach and food avoidance eating behaviours, the proposed Feeding Dynamic Intervention protocol largely focuses on the feeding relationship between parent and child and does not additionally consider other aspects of the FFE (apart from eating context), as have been shown to also be related to children’s eating behaviours and obesity status (section 2.3). [309, 310] Further to this, the use of the child feeding questionnaire (CFQ) within this intervention protocol may limit the results produced since this feeding practice scale does not capture both overt and covert restriction, as is likely to be particularly important in understanding opportunities to modify children’s eating behaviours (section 2.3.1.8). [309] Additional details of the Feeding Dynamic Intervention and NOURISH protocol, are presented in table 4.

Targeting an obesity prevention intervention towards children’s eating behaviours as a surrogate endpoint is likely to have several other potential benefits for researchers as well as participants. For researchers, measuring eating behaviours is highly convenient in comparison to measuring anthropometrics, since administering pre-validated eating behaviour survey tools, such as the CEBQ, can be done remotely. This is particularly advantageous in recruiting samples that are geographically diverse, as will assist to overcome current issues related to homogenous samples. For participants, targeting children’s eating behaviours has the potential to beneficially shift attention away from a focus on body weight which can result in preoccupation with body image and negative stereotypes. It may also shift attention away from labelling foods as ‘good’ or ‘bad,’ which can contribute to detrimental stigmatisations, guilt surrounding food and eating, and other negative health behaviours. [14, 236, 312-315] It is further likely that focusing attention on eating behaviours will simultaneously result in improvements in child diet quality (e.g. reduced intake of non-core, discretionary foods and increased intake of fruits and vegetables), as has been seen cross-sectionally and is supported experimentally in results from a 2017 review of experimental studies that aimed to improve child diet quality through changes in children’s eating behaviours (as conceptually captured in this paper as ‘liking’ ‘preference’ and ‘food neophobia’). [67, 316] Strategies used to change children’s eating behaviours in this review included parent’s use of control (which increased preoccupation, preference, and subsequent intake of the restricted food item), non-responsive feeding strategies such as rewards (which negatively impacted on child ‘liking’ of the reference food and increased ‘preference’ for the reward food), social facilitation (e.g. role modelling; which can have a positive or negative effect on child food preference), sensory lessons (which did not appear to greatly affect food preferences, but slightly decreased neophobia), and availability and accessibility (repeated exposure to fruit and vegetables effectively increased children's intake with a sustained effect). [316] Other macro-level strategies such as branding and food packaging, school gardens and cooking programs were also reviewed in this study, however, they are beyond the scope of this thesis.

In consideration of the evidence presented and the potential benefits, there is a strong argument that children’s eating behaviours are a suitable target for intervention that could act as a surrogate endpoint in obesity prevention during early childhood. As eating behaviours are theorised to hold an intermediary role in obesity development during early childhood it is further likely that achieving differences in children’s eating behaviours will occur more readily than differences in child weight. This is a further advantage of targeting children’s eating behaviours given the logistical constraints faced during interventions.

Table 4: Intervention studies on eating behaviours in young children (≥ 5 years of age)				
Reference	Sample	Intervention/ Outcome Focus	Assessment Measure/ Protocol/delivery	Results
Daniels, et al., (2009) [250] Daniels, et al., (2012) [317] Daniels, et al., (2013) [233] Daniels, et al., (2014) [308] Daniels, et al., (2015) [307] Magarey, et al., (2016) [307]	n=698 first-time mothers Child: 4 – 7 months old (module 1), 13 – 16 months (module 2) Follow up – 9 months post; 18 months post; 3.5 years post (2 years of age) **Australia**	**NOURISH RCT** Infant intake (type and amount of foods), food preferences, feeding behaviour and growth and self-reported maternal feeding practices, parenting practices and efficacy	Social cognitive theory Anticipatory guidance: Parent education and peer support group sessions (face to face) 12 sessions (2 modules of 6 fortnightly sessions) 6 months of maintenance contact Measures: - CFQ - PSFQ - CEBQ - Anthropometrics - Demographics	Post intervention [233] - More responsive feeding practices (p values, 0.033 to <0.001) - Less controlling feeding practices (p< 0.001) - Lower instrumental feeding practices (p< 0.001) - Increased perception child was mostly/only responsible for how much they ate vs. parent responsible (p < 0.001) - No difference in food refusal - No difference in child BMI (p=0.23) At follow up 6month post module 1 (child 14months) [317] Control group: - more rapid weight gain from baseline to follow-up (p=0.014) - higher BMIz (p=0.009) - more likely to report using non-responsive feeding practices (using food as a reward, p=0.001; or using games, p<0.001) 2 years follow up [308] Intervention group: - higher on satiety responsiveness (3.12 v 3.01, p= 0.03) - lower on emotional overeating (1.48 v 1.60, p= 0.009) - lower fussiness (2.46 v 2.62, p= 0.01) - liked more fruits (p=0.008) - had exposure to a wider variety of vegetables (p= 0.008) - more limited in the number of “liked” and “tried” non-core beverages (p=0.03 and 0.01) - greater use of autonomy encouragement (p=0.002) - no difference for warmth, irritability or overprotective parenting 3.5 years follow up [307] - more appropriate responses to food refusal (p ≤ 0.05) - less non-responsive feeding practices (p<0.05) - more responsive feeding strategies (p =0.006) 3.5 years follow up [307] - No difference in child BMI

				- Lower food responsiveness (2.3 vs 2.4, p=0.04) - Higher satiety responsiveness (3.1 vs 3.0, p=0.04) - Higher preference for fruit (74.6% v 69.0%, liked, p< 0.001) - Higher intake of fruit and vegetables (15.3 vs 14.5, p=0.03)
Eneli, et al., (2015)[309] Eneli, et al., (2015) [310]	2 – 5 years 12 week intervention Pilot sample n= 14 (1 x 90min session) **US**	**Feeding Dynamic Intervention (FDI) RCT** (wait list control) Improvements in children's self-regulated eating, energy compensation, satiety responsiveness, and caregivers' feeding practices	Intervention: Face-to-face (6 x 75 min sessions) Measures: - Anthropometrics - EAH - COMPX - CEBQ - CFQ - CFRS	Protocol only – no results Pre- Post Pilot Study 1 Increase in response to items: - *I only prepare food for my child that she/he likes to eat* (p=0.004) Decrease in response to items: - *I allow my child to have other food whenever she/he doesn't like the meal* (p=0.006) - *I try to make my child eat everything on her/his plate* (p=0.030) - CFQ scales: Restriction (p=0.000), pressure to eat (p=0.01), Monitoring (p=0.006)
Intervention Studies on obesity in young children (≥ 5 years of age)				
Reference	Sample	Intervention/ Outcome Focus	Assessment Measure/ Protocol/delivery	Results
Campbell, et al., (2008) [65] Hesketh, et al., (2013) [318] Campbell, et al., (2013) [312] Cameron, et al., (2014) [319]	n= 542 first-time parents (n=492 at follow up) 15 months intervention Child enrolled at 4 months of age (Data at 4, 9, and 20 months of age) Follow up – 2 years and 3.5 years post intervention (child ages ~ 3.5 and 5 years) **Australia**	**InFANT RCT**	Anticipatory guidance: Parent education and peer support group sessions (face to face; DVD, text message & mail out follow up) 6 sessions (delivered at 3 month intervals; 2 hours) Measures: - Child diet (3 × 24-hour recalls) - Child physical activity (accelerometry), - Child TV viewing (parent report). - Sedentary behaviour (parent report) - Home Food Environment (Nutrition Knowledge Questionnaire, CFQ, CFSQ) - Family physical activity and sedentary environment (checklist) - Anthropometrics (BMIz, waist circumference measured)	At 9 months intervention group children: - less consumption of noncore drinks (odds ratio = 0.48; p = 0.034) - No differences in fruit, vegetable, savory snack, or water consumption or in BMI z-scores or physical activity. At 20 months intervention group children: - consumed fewer grams of noncore drinks (mean difference = –4.45; p = 0.01) - consumed fewer grams of sweet snacks (mean difference = –3.69; p = 0.008) - viewed fewer daily minutes of television (mean difference = –15.97; p = 0.002). - Intervention effects on vegetable consumption and sweet snack consumption greater in children with higher educated mothers - Intervention effects on water consumption greater in infants with lower educated mothers - No differences in fruit, vegetable, savory snack, or water

			- Demographics	consumption or in BMI z-scores or physical activity
Campbell, et al., (2016)[320] Downing, et al., (2017) [321]	n= 206 33 months intervention Child enrolled at 3 months – 36 months of age **Australia**	**InFANT EXTEND RCT**	Anticipatory guidance: Parent education and peer support group sessions (face to face and **online;** emailed newsletters (n=6), webpage & Facebook® group [facilitated for one hour per week; mean facilitator posts 31.7 (SD 4.1)]) Measures: - Dietary intake (FFQ) - Sedentary behaviour - Physical activity - Home Food Environment (Nutrition Knowledge Questionnaire, CFQ, CFSQ) - Family physical activity and sedentary environment (checklist) - Anthropometrics (BMIz, waist circumference measured) - Demographics	Facebook® group: - 57.3% (n=149) of eligible parents joined the Facebook® group - Facebook® group members less likely to be working part-or full time and more likely to be keeping house/raising children full time (p=0.005) - Facebook® group size ranged from 2 – 10 participants - 75.0%, 50.0%, and 43.5% of participants reported the Facebook® group to be quite useful or very useful at completion of each of sessions 4, 5, and 6 (18 months old) Compared with non-Facebook®, Facebook® group - higher fruit intake (p<0.05) - no significant differences for BMI z-score, waist circumference z-score, vegetable intake, water intake, non-core drink intake, non-core sweet snack intake, non-core savory snack intake, television viewing, or physical activity
West, et al., (2010) [322]	n= 101 children 4 – 11 years 12 week intervention 1 year follow up **Australia**	**Lifestyle Triple P RCT** (waitlist control and intervention) To reduce children's risk of chronic weight problems by increasing parents' skills and confidence in managing children's weight-related behaviour	Face-to-face sessions (9 x 90 mins + 3 x 20 min phone call) Primary Outcomes: - Child BMIz Measures: - Anthropometrics (measured) - Lifestyle Behaviour Checklist (parenting self-efficacy) - Parenting Scale (ineffective parenting) - Client Satisfaction Questionnaire - Session Content Checklists	Intervention group Pre – Post intervention: - Significant decrease in child BMI (p<0.001) - Significant decreased in weight-related problem behaviour (p<.001) - Significant decrease in ineffective parenting decreased (p<.001) - Significant increase in parenting self-efficacy (p=0.002) Post intervention – 1 year follow up: - Significant decrease in child BMI (p<0.001) - Significant decreased in weight-related problem behaviour (p<.001) - Significant decrease in ineffective parenting decreased (p<.001) - Significant increase in parenting self-efficacy (p<.001)
Hammersley, et al., (2017) [323] Jones, et al (2011) [324]	Child 2 – 5 years 10 week intervention 6 month follow up **Australia**	**Time2bHealthy RCT** Assess efficacy of an online parent-focussed healthy lifestyle program for reduced child BMI	Social cognitive theory Intention to treat 10 week **online** (5 x 30min interactive modules via website, email, Facebook® group) compared with comparison condition (fortnightly emails) - Goal setting (SMART goals) - Tailored feedback - Email triggers	Protocol only – pilot results (47 parent-child dyads) Pilot Outcomes: - All participants agreed/ strongly agreed the program was interesting, easy to understand, content was relevant, sufficient, helpful and practical - Program and module schedule were appropriate/ highly appropriate - 80% indicated goal setting was helpful - 63% indicated emails were helpful

			Measures: - Anthropometrics (BMI) - Physical activity (accelerometer) - Dietary intake (24-hour recall and questionnaire via app.) - Sleep (Accelerometer and questionnaire) - Screen time (questionnaire) - Demographics - Parent self-efficacy (questionnaire) - Parent role modelling (PARM) - Child feeding (CFQ)	- Parent knowledge of dietary intake and physical activity improved - Parent report child dietary intake and physical activity improved - BMI not measured
Wen, et al., (2012) [325] Wen, et al., (2015) [326]	n= 667 first time mothers and their infants (birth – 2 years) **Australia**	**Healthy Beginnings RCT** Reduce obesity outcomes in socially and economically disadvantaged	Intention to treat protocol 8 **home visits** (1 in antenatal period, and 1, 3, 5, 9, 12, 18 and 24 months after birth) Key messages: - Breast is best - No solids for me until 6 months - I eat a variety of fruit and vegetables every day - Only water in my cup - I am part of an active family Measures: - Child BMI (measured) - FFQ - TV viewing & outdoor play (parent report) - Mother nutrition & physical activity - Demographics	Intervention group: - significantly lower BMI (difference between intervention and control group of 0.29 (95% confidence interval −0.55 to −0.02; p=0.04) - significantly more likely to eat one or more servings of vegetables a day than those in the control group (83%, p=0.03) - significantly less likely to be given food for reward (62% v 72%, p=0.03) - significantly lower dinner in front of TV, or having the TV on during the meal (56% v 68%, p=0.01; and 66% v 76%, p=0.02; respectively) - significantly less children watching TV for more than 60 minutes a day (14% v 22%, p=0.02) - no significant differences in consumption of fruit, consumption of "junk food," or time spent in outdoor play
Wen, et al., (2017) [327]	First time mothers and their infants (birth – 2 years) **Australia**	**Communicating Healthy Beginnings Advice by Telephone (CHAT)** 3-arm parallel RCT (2 intervention arms and 1 control arm)	Arm 1: 2-way SMS (mailed stage plus 2x per week for 4 weeks) Arm 2: Telephone support (6 stage mailed followed by phone call [30mins]) Arm 3: Control (usual community health care) Phase 1 - intervention phase (outcomes measured at 12 months of age) Phase 2 - follow-up phase (no further intervention; outcomes measured at 24	Results not published - Protocol only

			months of age) Primary outcomes: - an increased breastfeeding rate and duration - introduction of the solids at 6 months - a reduction in child BMI z-score at 12 and 24 months; Measures: - Anthropometrics (measured) - FFQ - Screen time - Mothers nutrition & physical activity	
Taveras, et al (2011) [328]	n=475 (271 intervention) (1 year) Children 2 – 6 years (overweight/obese) n= 445 (93%) had 1 year outcomes **US**	**High Five for Kids RCT**	Chronic Care Model 4 x Motivational interviewing sessions (25 min), & 3 x 15-minute **telephone calls** Modules targeting: TV, fast food, and sugar sweetened beverages Control: usual care	Intervention group: - lesser, non-significant increase in BMI (−0.21 kg/m2; p=0.15) compared with the control group (0.31 kg/m2 Vs and 0.49 kg/m2) - BMI change among females (−0.38 kg/m2; p=0.03) but not males (0.04 kg/m2; p=0.89) - BMI change among low incomes (−0.93 kg/m2; p=0.01) but not higher income (0.02 kg/m2; p=0.92) - greater decreases in TV viewing (−0.36 hours/day p=0.01) - greater decreases in fast food (−0.16 servings/week; p=0.07) - 56% completed at least 2/6 intervention activities

Parental Feeding Style Questionnaire (PFSQ); Child Feeding Questionnaire (CFQ); Children's Eating Behaviours Questionnaire (CEBQ); Eating in the absence of hunger (EAH); Food Frequency Questionnaire (FFQ)
Caregivers Feeding Style Questionnaire (CFSQ); Australian Toddler Eating Survey (ATES); Longitudinal Study of Australian Children (LSAC); Parental Modelling of Eating Behaviours Scale (PARM); Caregiver Feeding Responsibility Scale (CFRS): Energy compensation scale (COMPX)
Blue shading indicates studies which included measures of Children's eating behaviours

2.4.3 Key intervention strategies and approaches

A 2017 systematic review and quantitative content analysis of family-based childhood obesity prevention interventions (pre-natal – 17 years), identified a total of 119 studies, 51 of which involved families of children 2 – 5 years. [329] Of the interventions targeting children 2 – 5 years of age delivered within the home, behavioural domains of focus included diet (100% of studies), physical activity (62% of studies), media use (69% of studies), and sleep (15% of studies), with many operating across multiple behaviour domains. [329] Interventions aiming to address the breadth of FFE variables and psycho-social variables identified to be of significance in relation to children's eating behaviours and obesity, however, are clearly lacking. In this review, interventions delivered in-person (n = 101, 85%) were more common than technology based interventions (n = 27, 23%), however, 14 interventions (12%) had both in-person and technology based components. [329] Intervention duration was categorised as less than 3 months (29%), between 3 months and 11.9 months (40%), and more than 12 months (28%; 3% were of unclear duration). [329] The majority of interventions utilised theory (n = 85, 71%), most commonly the social cognitive theory (SCT) (n = 49, 41%), with many utilising multiple theories (n = 34, 29%). [329] While this review did not report on the effectiveness of these interventions, this information provides a nice overview of current interventions from which more specific details have been explored below. [329]

2.4.3.1 Family-based intervention

While there is no gold standard for early childhood obesity prevention interventions, the majority of the interventions included in the fore mentioned review [329] appear consistent with the gold standard of treatment for childhood obesity, as is considered to involve behaviour therapy, typically provided to parents and child, weekly, for 4–6 months. [329-331] In this regard, there is strong evidence to support the benefits of interventions primarily involving parents, as they play a central role as gatekeepers of the FFE. A review conducted in 2012 supports this perspective through examination of the effectiveness of family-based (micro-level) childhood obesity interventions (methodological rigour and treatment) over the past 35 years. [332] Although it is acknowledged that the results of this review, which included a total of 15 RCTs for children and adolescents aged 2 – 19 years (67% involved only 2- to 12-year-old children), may not be directly transferable to obesity preventions, findings indicated that family-based models of intervention produce the most positive effects regarding weight loss in overweight children. [332] Four major types of family-based interventions were identified in this review, of which, a behavioural approach to family-based healthy lifestyle intervention consistently achieved better outcomes than the other three types of family-based intervention (behavioural approach plus parent education, family therapy, and family therapy plus family-based psycho-education). [332] It was noted, however, that the latter three types of family-based intervention were relatively new and thus potentially under-represented in the literature. [332]

In terms of the behavioural approach to family-based healthy lifestyle intervention, this type of intervention incorporates information about authoritative parenting styles (section 2.3.1.9) and child management to intervention based on behavioural theory. [332] This type of intervention approach is likely to similarly be beneficial in obesity prevention based on the literature reviewed in section 2.3. Consistent with this, critical inputs in childhood obesity prevention interventions, as components considered necessary to produce the expected effects, have similarly been described to include parental knowledge, attitudes, and beliefs towards food, feeding habits, and energy expenditure, along with core behaviour change techniques such as self-monitoring, goal-setting, stimulus control (e.g., structuring the home environment to support healthful eating behaviours), and problem solving skills. [330, 331] Given the importance of parents in these critical inputs, as consistent with the concept of parents as key gatekeepers of the FFE, family-based obesity prevention interventions that are significantly focused on the family dynamic within the context of the FFE are likely to be more effective than interventions involving children only.

Such positive impacts of family-based interventions can be seen in table 4, with results of the InFANT and NOURISH RCT which implemented parent focused anticipatory guidance protocols within the FFE to produced significant changes in aspects of the FFE that are likely to have positive impacts on child weight and eating behaviours. Similarly, the Feeding Healthy Food to Kids RCT implemented in families of children 2 – 5 years (n=146) living in rural Australia, showed significant decreases in monitoring of child eating (4.2 vs 4.6, $p<0.05$) and significant increases in the parenting dimension *warmth* (0.19, $p=0.02$), from baseline to 12 months follow up, following the provision of child feeding resources (including books, brochures, CD; email/text/phone reminder to use resources). [333, 334] Haire-Joshu, et al., (2008), also produced increased intake of fruit and vegetables (intervention effect adjusted^2=0.20, $p=0.05$), increased availability of fruit and vegetables within the home (intervention effect adjusted^2 =0.19, $p=0.01$), and increased nutrition knowledge (intervention effect adjusted^2 =0.14, $p=0.01$), following a home-visit intervention protocol among 759 families with children 2 – 5 years of age (US). [223] Although unexpectedly, decreases in used of non-coercive feeding practices were also seen following this intervention (intervention effect adjusted^2 = -0.12, p=0.02). [223] While similar results are not consistent across all studies in this area of research, several studies also reported that comparable parent-driven changes within the FFE resulted in positive changes in weight status in intervention groups following intervention (table 4). [322, 325, 326, 328]

Given the pivotal role of the FFE in relation to children's eating behaviours and obesity status, interventions which work directly with parents and are family focused show significant promise in effecting change in FFE, as a likely means to alter children's eating behaviours and thus reducing obesity risk.

2.4.3.2 Behaviour change techniques

2.4.3.2.1 Goal orientated intervention

Whilst operating within the family, intervention goals are a critical input necessary to ensure both participants and researchers are clear about where the intervention is headed and that the desired behaviour change outcomes have been attained. As highlighted in Appendix 4, interventions which embed aspects of goal setting and behaviour change strategies produce positive results and are well accepted by parents. [324, 331] Frameworks for goal setting, such as the *SMART Goal* (Specific, Measurable, Achievable, Realistic, and within a *Timeframe*) framework, are useful in aiding the development and attainment of goals and have been seen to be used in family-focused early childhood interventions. [323] For instance, in a pilot intervention of parents with children 2 – 5 years, SMART goal setting activities (10 goals during a 5 module intervention; over 10 weeks) were perceived as helpful by 80% of participants. [324] In this regard, the SMART goal frameworks can be used to guide both long and short-term goals, as relevant to behaviour change theory. In practice, however, it is an accumulation of short term, *stretch goals* that results in attainment of long-term behaviour change. Sutton (2000) explains that stretch goals are used, not to drive short-term action, but to inspire longer term innovation processes aimed at making desirable outcomes, that are currently impossible, achievable at some future time. [335] On this note, *triggers,* as described as part of Fogg's (2011) behaviour model, can be used to facilitate participation in behaviour execution and attainment of stretch goals. [331, 336] Fogg (2011) suggests that triggers can be *hot* or *cold*, whereby hot triggers are presented when users can take action, (e.g. at a time most likely to be engaged in behaviour), while cold triggers are presented when users cannot take action at that moment (e.g., at a time when the behaviour is unlikely to be executed). [336]

2.4.3.2.2 Tailored intervention

Building on the concepts of goal orientated interventions, interventions also benefit from tailoring information and feedback towards individual determinants of behaviours and engagement with intervention protocol. [337, 338] As has been discussed throughout section 2.3, children's eating behaviours interact with FFE variables, with parents as important gatekeepers and facilitators of such environments and subsequent interactions. From this understanding, researchers can facilitate tailored behaviour change techniques directed at children's eating behaviours, via the FFE, with parent's behaviours as key agents of change. Such tailored strategies for behaviour change recognise that, despite common elements within the FFE that relate to childhood obesity and deviations in eating behaviours, a 'one-size fits all' approach to obesity prevention is likely to be inadequate in addressing unique contributing factors surrounding obesity development and as such, are likely to be ineffective in achieving required behaviour change. In particular, intrapersonal variables that play a contributing role in deviations in eating behaviours and obesity development (e.g. parental stress, single parent status, general disadvantage/low SES; section 2.1) highlight circumstances in which tailored strategies are likely to be particularly advantageous.

In addition to tailored intervention strategies, tailored behaviour change techniques are important to maximise intervention effect. Tailored behaviour change can be achieved through, for instance, application of cognitive behaviour therapy (CBT), as exampled by Militello, et al., (2014) [331]; by linking behavioural determinants to behaviour change techniques and scaffolding intervention tasks to extend beyond traditional 'knowledge attainment,' which is unlikely to be sufficient to drive behaviour change. [331, 336] CBT consists of three core principles; (1) cognitive activity affects behaviour, (2) cognitive activity may be monitored and altered, and (3) desired behavioural change can occur through cognitive change. [339] In order to implement such CBT practices within an intervention, in addition to scaffolding behaviour change tasks, the researcher has a responsibility to promote behaviour change and outcome attainment through the provision of tailored feedback to participants that supports development and application of self-reflection and self-assessment that is conducive with individual socio-cultural ideologies, dietary practices and construction of FFEs. [340, 341] Such tailored feedback should reflect the participants involvement with the task, the process implemented, reflective practices employed/required, and the participant as an able person. [341] Tailored interventions are further likely to support participant engagement, by allowing them to make changes that they are ready and capable of making, with regards to behaviours and outcomes of relevance to them and their individual goals. [331, 336] Further details reflecting implementation of such behaviour change techniques within interventions can be seen in Appendix 4. [331]

As this section has presented, interventions that work with parents to implement a family focused intervention protocol, that are goal orientated, apply triggers, and are tailored through use of cognitive behaviour change techniques and therapies, are likely to be successful in driving change within the FFE that are likely to positively influence children's eating behaviours and obesity risk. These key intervention strategies and approaches are used to guide the development of an intervention portfolio in section 5.2.

2.4.4 Theoretical model selection

From this sound theoretical basis of effective intervention attributes, intervention mapping can progress which includes the selection and justification of relevant theoretical models and schematic planning, as consistent with literature wide practices. [46, 50, 342] The schematic plan graphically draws together the intervention objectives, the casual determinants within the FFE (section 2.3), and application of the relevant theoretical models to initiate intervention adoption and behaviour change.

2.4.4.1 Theoretical frameworks for changing eating behaviours

The use of theoretical models is particularly advantageous in intervention design as it assists in identifying constructs to be targeted (e.g. self-efficacy), as well as mechanisms underpinning behaviour change techniques and participants most likely to benefit from intervention (e.g. participants with low levels of self-efficacy). [343, 344] Thus, interventions which use theoretical models are largely considered more effective than those that do not. [344]

Given this and in light of the modifiable and mediating factors in early childhood obesity development identified throughout this thesis, the health belief model (HBM) has been selected as an appropriate theoretical model for use given the strong emphasis of this model on understanding barriers and facilitators of health behaviours. [345] Additionally, the social cognitive theory (SCT) has been selected as it shares many similarities with the behavioural susceptibility theory, as has been used to explore and understand factors which contribute to childhood obesity, by acknowledging interactions between the person, environment and health behaviours. [346, 347] In this regard, both the HBM and SCT appear to be appropriate models from which to frame an obesity prevention intervention, operating through the FFE, since both models predominately operate at the interpersonal level of the socio-ecological model, while recognising macro-environment influences. That is, while the HBM assists to understand motivating factors of participation in health-related behaviours, the SCT attempts to decode an individual's cues to act. [46, 345-347] These models were additionally referred to, and selected by, Uesugi, et al., (2016), due to their extensive support and use in early childhood interventions across the literature. [46]

2.4.4.2 The health belief model

The HBM is a commonly used psychological model that attempts to explain and predict health behaviours. [348] The model suggests that an individual's likelihood of engaging in health related behaviours is determined by their perceptions under the domains; perceived susceptibility; perceived severity; perceived benefits; perceived barriers; cues to action; and self-efficacy. [348, 349] Although, since the development of this model by Rosenstock in 1966, the HBM has undergone further development with researches suggesting the inclusion of domains such as self-identity, perceived importance, consideration of future consequences, and concern for appearance. [348] With the inclusion of these additional domains the HBM has been seen to lead to a 78% increase (from 40 – 71%) in predictive capacity compared with the original model. [348] Thus, within the realms of health interventions, understanding perceptions within these domains provides a framework from which behaviour change interventions can operate and motivations to participate in behaviours can be understood. [348] In particular, the domains 'future consequences', 'self-identity', 'concern for appearance', 'perceived importance', 'self-efficacy', and 'perceived susceptibility' have been shown to be the most significant predictors of dietary behaviours in a quantitative study of 576 participants. [348] In this study self-efficacy (one's confidence in their ability to perform the health behaviour), emerged as the strongest predictor of healthy dietary behaviours (β=0.39, effect size f^2 = 21%, $p \leq 0.01$), showing both a direct and indirect relationship, via the domain *barrier.* [348] "This means that self-efficacy not only increased an individual's tendency of adopting a healthy behaviour but also reduces the inhibiting effect of barriers on behaviour performance."

[348] Thus it was concluded that interventions designed to increase self-efficacy are likely to be highly effective in bringing about behaviour change. [348]

According to Bandura (1994), “the most effective way of creating a strong sense of efficacy is through mastery experiences. Successes build a robust belief in one's personal efficacy. Failures undermine it, especially if failures occur before a sense of efficacy is firmly established.” [350] In addition to this, Bandura (1994) suggests that vicarious experiences provided by social models are effective in creating and strengthening self-beliefs of efficacy. [350] That is, “seeing people similar to oneself succeed by sustained effort raises observers' beliefs that they too possess the capabilities to master comparable activities required to succeed,” (Bandura, 1994). [350] Finally, Bandura (1994), states that “social persuasion is a third way of strengthening people's beliefs that they have what it takes to succeed. People who are persuaded verbally that they possess the capabilities to master given activities are likely to mobilize greater effort and sustain it than if they harbor self-doubts and dwell on personal deficiencies when problems arise.” [350]

2.4.4.3 The social cognitive theory

With this importance of social context in developing self-efficacy in mind, the SCT was additionally selected as an appropriate theoretical model to support understanding of, and consequently change in, parent’s behaviours within the FFE. That is, the SCT similarly acknowledges the importance of social context in developing self-efficacy as a key determinant of behaviour, but further recognises the influence of a person's individual capabilities, other individual factors, as well as environmental factors (barriers and facilitators). [346] This reciprocal relationship between an individual‘s experience (cognition, affect, behavioural patterns and biological events), their social context, and their interaction with the environment in determining behaviour, as a key construct of the SCT, is referred to as reciprocal determinism. [346] Further constructs of the SCT include behavioural capacity, which refers to a person's ability to perform a behaviour based on knowledge, skills, and learned consequences of their pervious behaviour; observational learning, which asserts that witnessing of behaviour enables individuals to reproduce the observed action and complete the behaviour successfully; reinforcements, which refers to internal and external responses to a behaviour that intern impacts the likelihood of the behaviour being continued or discontinued; and lastly, expectations, which refers to the anticipated consequences of a personal behaviour. [346]

Based on these constructs, the SCT has been applied at an intervention planning level to support behaviour change through social support, by instilling expectations, self-efficacy, and using observational learning and other reinforcements. [347] Specifically, the effectiveness of the SCT in interventions can be seen in the NOURISH RCT (table 4), which successfully increased parents use of responsive feeding practices, decrease consumption of sweet snacks, and lower daily television viewing time. [312] The SCT has also been used to guide development in several other childhood obesity prevention interventions, with attention given largely towards developing parent's self-efficacy, as a key construct of this theory (table 4). [351, 352]

2.4.5 Intervention development

As detailed in the literature reviewed in section 2.4.2, interventions targeting obesity during early childhood have produced inconsistent results (table 4). One proposed reason for this, related to sub-optimal intervention implementation. [306] Consequently, interventions that devise methods to overcome issues related to implementation, such as modes and method of delivery and ongoing participant engagement, may have greater outcome success. Interventions that are delivered in small doses when convenient to participants to accommodate life exigencies, such as those of parenthood, are particularly appealing in overcoming issues related to sub-optimal implementation. [321, 353] In this regard, interventions delivered using technology-based platforms (e.g. websites, emails, phone applications, social media sites), as a unique digital resource that has the capacity to enable health related behaviours (section 2.3.2.2), holds much promise as a new and modern way to deliver interventions.

Furthermore, the use of technology in intervention delivery has the potential to address major challenges faced in traditional interventions, including the reliance on small, geographically related and highly educated samples, as well as rates of attrition due to scheduling conflicts and the burden of attending face-to-face intervention sessions. [354] Technology based interventions are also likely to be particularly supportive towards the learning needs of adults, who are understood to be self-directed and bring an array of life-experiences to learning, while operating in a self-directed way. [321, 353]

2.4.5.1 Technology based interventions

Studies that have taken advantage of the potential of technology-based interventions have generally proved to be a feasible and acceptable means of producing behaviour change (table 4 and Appendix 4). For example, a 2015 systematic review of technology based paediatric (5 - 19 years of age) obesity interventions showed that although few intervention effects were observed on weight status in the 17 studies included, increases in physical activity, self-reported breakfast consumption, fruit and vegetable consumption, adherence to treatment, and self-monitoring, were seen. [355] Similarly, a 2017 systematic review into the overall effectiveness of mobile health technologies employing self-monitoring to decrease paediatric obesity (5 – 17 years of age), showed that the nine included studies had a small, but significant effect on weight, and a small to medium significant effect on diet. [356] Although the direct impact on child weight appears limited (as consistent with traditional interventions; section 2.4.2), the results of these reviews add support for the use of technologies as an effective means to deliver interventions that bring about changes in health-related behaviours. Additional benefits of technology-based interventions which may assist in facilitating behaviour change include flexibility around when participants can engage with the intervention (as likely to be particularly important to busy parents), and the ability to reach a geographically diverse sample of participants.

Specifically, technology-based platforms such as websites and many phone applications (apps.) are suitably designed for one-way communication, whereby intervention participants can engage passively with the intervention protocol and are self-reliant on reflection and application of core messages. An Australian study which evaluated websites containing early childhood feeding and obesity related content specifically showed that of 14 relevant websites, 8 contained self-managed information, 8 contained (one-way) interactive features (e.g. quizzes), 8 contained useful links and resources, while only 3 contained access to asynchronous discussion and no sites contained information about face-to-face or online support groups. [357] Further to this, no sites contained goal setting information or activities, which largely limits the potential for application of content. [357] The potential for technology-based platforms, such as websites, to provide ‘tailored’ intervention messages and strategies also appears to be overlooked. That is, while maintaining the passive capacity of a website, ‘streams’ of content could also be used to ‘tailor’ information and resources according to participants unique needs. [357]

In addition to this passive capacity of technology-based platforms, social media platforms additionally offer benefits in technology-based intervention delivery as a two-way communication platform that allows active exchanges between researchers and participants. Although still relatively novel, with a 2014 review into the use of social media for public health practice identifying only 5 studies which implemented experimental designs via social media platforms, these platforms appear to be feasible and acceptable to participants while allowing observational and peer learning through the interactive features of these platforms. [358] Similarly, to websites, emails and phone apps., social media platforms allow a large degree of uniformity in intervention implementation, however, also allow more 'personalised' (tailored) information through direct communication and specific feedback to participants. Such personalised elements of online intervention were indicated to be of importance to participants within a focus group of 27 Australian parents of young children (2 – 5 years). [357] Within this focus group it was indicated that parents wanted such online interventions to incorporate information on how to implement recommended strategies and practices (as also indicated to be absent from current websites [357]), elements for family involvement, and credible information while also being easy to read and use/navigate. [357]

Despite the small number of studies that have utilized social media platforms for intervention delivery, a 2013 systematic review into the benefits of social media health communications specifically identified six key benefits, including; (1) increased interactions with others, (2) more available, shared, and tailored information, (3) increased accessibility and widening access to health information, (4) peer/social/emotional support, (5) public health surveillance, and (6) potential to influence health policy. [359] Potential limitations of social media interventions were, however, also identified, including concerns regarding lack of reliability, confidentiality, and privacy. [359] These concerns, as well as the further details reflecting the potential benefits of social media and other technology-based platforms for intervention implementation have been discussed below.

2.4.5.2 Benefits of technology-based interventions

The potential of social media and technology based platforms for delivering interventions are particularly enhanced given the high accessibility of the internet, which is available to 87% of Australians, and the wide reach of social media, which is used by 69% of those with internet access (section 2.3.2.2). [286] The high popularity of smart phones and internet enabled devices further makes the internet and consequently social media sites, accessible anywhere and anytime, thus readily available for intervention use. [286] As mentioned, the differing, interactive features of social media platforms compared to other technology-based platforms (e.g. websites and phone apps.), further makes social media appealing to incorporate into intervention delivery.

While a vast number of social media platforms exist, as of September 2016, Facebook® was Australia's most popular social media platform, accumulating 95% of social media usage. [286, 360] Further to this popularity, most Facebook® users login to Facebook® multiple times per day, indicating a high level of engagement with this platform. [286] Facebook® is slightly more popular amongst females (3% higher than males) and those under 40 years of age (75% – 66% compared with 52% - 20% amongst those over 40 years), as the key demographic for an early childhood obesity prevention intervention. [286] The distribution of users across metropolitan verse regional areas is fairly consistent, which adds to the appeal of Facebook® as a means to reach a geographic diversity of participants and offer a 'user-friendly' intervention mode that participants are able to engage with in small but frequent doses at the participants discretion. [286, 353]

Further to this, through the delivery of interventions via Facebook® and other technology-based platforms participants have more control over their 'dosage' and 'self-streaming' in terms of being able to access content of interest and relevance to them. This ability of users to self-select content, allows technology and social media-based programs to become 'tailored' to the individual participants needs, while the availability of sophisticated data and meta-data allows for detailed monitoring and tracking of content accessed by participants. In addition to this, given the instant access of social media and websites through smart phones and internet enabled devices, program delivery can readily include the use of prompts and triggers for goal-oriented action and behaviour execution, as discussed in section 2.4.3.2.1. [331, 336]

Of the few studies that have embraced the opportunities of social media platforms for intervention, the Grow2Gether RCT implemented a Facebook® peer-group intervention, facilitated by a psychologist. [361] The intervention, which featured weekly videos addressing child feeding, sleep, parenting, and maternal well-being via Facebook® showed significant improvement in child feeding behaviours compared to the control group ($p=0.01$, effect size=0.45; $n=87$), with intervention mothers significantly less likely to pressure infants to finish food. [361] Differences in other outcomes, including maternal feeding beliefs and infant weight-for-length, were not observed. [361] Gruver, et al., (2016), further suggests Facebook® based interventions to be both feasible and acceptable in mothers of young children, based on an 8 week pilot Facebook® based peer group intervention for mothers, designed to prevent paediatric obesity and promote healthy beginnings in infancy. [362] In this pilot, participants were encouraged to use the Facebook® group to chat, ask questions and share photos and videos of themselves and their babies practicing healthy behaviours. [362] These interactive features of Facebook® were similarly utilised in the recent InFANT extend study, which invited 206 first time parents in the intervention arm to join a Facebook® group as a platform to compliment face-to-face intervention sessions. [321] Of the participants invited into this group (from face-to-face intervention groups), 57.3% (149) accepted the invitation. [321] The Facebook® group was largely used to confirm and arrange face-to-face intervention sessions, but was also used to provide 'triggers' to participants and allow participants to ask questions and interact with each other. [321] The *Time2bHealthy* intervention protocol, designed for Australian parents of children 2 – 5 years, similarly plans to capture the varied potential of technology-based interventions by offering participants access to 6 website based modules (30 minutes in length, over 11 weeks) that involved reading text on each topic, watching videos, completing activities and setting SMART goals. [323] While the results of this intervention are yet to be published, the website will be used to provide feedback to participants and email prompts used to encourage participants to engage with the website content. A private Facebook® group will additionally be used to allow two-way communication between participants and researchers. [323] Despite the comprehensive nature of this protocol, this study does not aim to capture children's eating behaviours, nor does it intend to make distinction between parents' use of overt and covert restriction in its measures of parent feeding practices. These are significant limiting features of this study which could be addressed in future research.

2.4.5.3 Limitations and concerns

While the novel potential of social media and technology-based interventions hold much promise in enhancing traditional intervention delivery and implementation, they also bring with them new concerns and potential limitations. Concerns have been identified in relation to the privacy, confidentiality and authenticity of participants. [363] For instance, Facebook® users disclose substantial personal information through their Facebook® profile (e.g. name, birth date, location, relationships, place of work), which may be available to researchers and other participants. The use of privacy settings within Facebook® profiles can help to protect participants personal information from becoming public and consequently should be encouraged amongst intervention participants. Similarly, Facebook® groups, as often used within interventions, can be set to 'private' such that information shared within the group is only visible to approved members of the group.

Likewise, Facebook® group settings can be adjusted so that posts from group members must be approved by administrators (e.g. researchers) of the group before being visible to the remainder of the group. Such group settings should be considered for use in interventions delivered via Facebook® in conjunction with traditional ethical protocols and practices.

On this note, before research participants are invited to join a Facebook® group and disclose personal information, the researcher has a responsibility to inform the participants exactly what information will be used for research purposes. For instance, content contributed within a Facebook® group by intervention participants, such as comments, photos, poll responses, or other interactions (e.g. 'likes,' emoticons/emojis), could be collected and used as research data, as well as or instead of, formally collect information such as through surveys or interviews. [363] This availability of a diversity of data, while likewise novel, is likely to add a richness to the level of evidence able to be collected during interventions. Management and ethics around such data needs to be considered carefully by researchers.

Likewise, participants should be encouraged to consider what personal information they wish to disclose within a technology-based intervention and clear rules of engagement for participation within Facebook® groups, or similar, be established by researchers at the beginning of an intervention. While disclosure of personal information to strangers within group settings often similarly occurs within traditional, face-to-face interventions, the unique properties of social media sites such as Facebook® can give participants a sense of *virtual anonymity*. Such perceptions of anonymity due to the lack of physical presence could lead to participants disclosing more information than they would in a traditional setting, while for others it could lead to disclosure of less information, with much still unknown about the phenomenon. For instance, in the previously mentioned 8 week pilot Facebook® based peer group intervention, mothers concerns in regards to participating in the online group with people they had not met, varied, with 59% reporting they were unconcerned about it, however, for 10% it was reported to strongly affect their participation. [362]

Similarly, the use of technology to engage with research participants could also result in unique aspects of social desirability bias (reflective of participant authenticity), whereby participants take on a *digital persona* (e.g. facilitated through editing, photoshop, dishonest responses, falsifying personal circumstances). Although a meta-analysis by Dodou and de Winter (2014), suggested there was no differences in social desirability bias between online and offline surveys, this study did not extend to considering interventions conducted specifically via social media sites. [364] In this regard, researchers should also give attention to verifying the authenticity of research participants within technology and social media-based interventions (participants with *fake profiles*, as opposed to *digital persona)*, to protect the validity of the research project as well as the privacy of research participants.

While these concerns around the use of technology and social media for the delivery of interventions requires researcher attention and specialized planning considerations, these concerns and potential limitations are not considered to outweigh the potential benefits of these platforms, particularly in relation to reaching a geographically diverse sample, in reducing the burdens of traditional research, and improving implementation.

2.4.5.4 Participant recruitment

As stated, Facebook® is particularly appealing as an intervention platform as it offers ready access to a large, diverse population of participants. This reach of Facebook® has the potential to be beneficial for recruiting a diversity of participants into a research project (technology based or otherwise) and consequently in improving the generalisability of results. While the internet in general offers similar appeal in terms of reaching a large, diverse audience, the vastness of the internet is likely to dilute any recruiting efforts. On this note, Facebook® offers a high-quality advertising feature that allows researchers to target audiences based on age, gender, geographic locations, and interests. While this method of recruitment cannot determine the presence of *fake* Facebook® profiles, it will improve the authenticity of participants by directing advertising towards accounts that are actively engaging with content relevant to the research demographic.

Alternatively to Facebook® advertising, ‘snowball sampling’ has proved an effective and cost efficient way to recruit large numbers of participants through Facebook®. This method of recruiting occurs when Facebook® users invite ‘friends’ and Facebook® connections into the research project. This can occur directly or indirectly through *sharing, tagging* and *liking* the recruitment campaign but often requires high engagement of participants (usually with an incentive). [354] Given this, ‘snowball sampling’ as a method of recruitment has the significant pitfall of generating a sample that is homogenous and lacks diversity. [354] In reality, however, ‘snowball sampling’ is likely to incidentally occur alongside research recruitment using Facebook® advertising due to the innate nature of Facebook® interactions. Consequently, researchers should be aware of this risk of sampling bias when recruiting participants via Facebook®.

2.4.5.5 Participant engagement

Further to the appeal of Facebook® for intervention delivery and recruiting of participants, Facebook® is appealing for intervention use due to the capacity to operate synchronously (occur in real time; either audio/video or text), whereby participants and researchers interact at the same prearranged time, as well as asynchronously (not occurring at the same time), which allows greater flexibility for participants and researchers in timetabling, while also allowing researchers the opportunity to reflect on participants comments, questions and posts before responding. [363] This flexibility is likely to be a key benefit of Facebook® for intervention delivery that is distinct from the capacity of other technology-based platforms, such as websites, that tend to offer asynchronous opportunities only, as has previously been discussed. This flexibility to interact with interventions synchronously or asynchronously through Facebook® may further assist in overcoming issues of attrition, as common in traditional interventions due to scheduling conflicts or the program being offered too far from home. [365] In this regard, attrition rates have been reported to range from 27% to 73% in paediatric weight management programs delivered through traditional methods. [365]

Although specific rates of attrition within technology-based interventions are not available for comparison, since participants in technology-based interventions must be self-directed in their engagement, attention should be given to ensuring participants are sufficiently motivated to engage in the intervention protocol to maximise the opportunities of this platform. On this note, the use of Facebook® to deliver interventions appears effective in facilitating group dynamics, peer interactions and observational learning, as underpinning elements of behaviour change based on the SCT. [346, 363] Although the literature reflecting the use of Facebook® for behaviour change and/or health interventions is limited, wider fields of research provide insight into the effectiveness and potential of such groups. For instance, a qualitative study pertaining to the experiences of Third Culture Kids, explored the benefits of a Facebook® group as a platform to collect data and discussed the researchers role in facilitating such a group. [363] In this study it was reported that Facebook® groups offer much the same opportunity as face-to-face interactions, however, with the absence of non-verbal communication from participants (e.g. body language, verbal tones, facial expressions), researchers needed to use and interpret 'digital equivalent' forms and modes of communication such as emoticons and *reactions* (*likes/dislikes*, feelings) while also gauging when to move on to new topics, review previous topics, and 're-engage' participants as necessary. [363] Failure to effectively *read* non-verbal communication in Facebook® group settings, is likely to increase the risk of participants withdrawing from the research project and/or disengaging with the content. [354] For this reason, it is important that researchers using Facebook® groups for intervention delivery develop a good rapport with participants and work to maintain a productive, respectful group climate. Setting up clear guidelines for engagement, as discussed, will assist with this, as will ensuring participants are clear about the intervention expectations and protocol.

Achieving such a rapport and effective engagement within a Facebook® group further holds potential for the group to becoming self-sustaining at the end of the intervention period. This potential for groups to become self-sustaining is desirable to assist maintain the momentum of the intervention and support the behaviour change efforts of participants (as consistent with the premise of the SCT), as well as in assisting researchers collect follow up data. On this note, creating self-sustaining interventions may be enhanced in online interventions through the use of intervention champions (or opinion leader) who take the lead in facilitating the intervention in the absence of the researcher, as discussed below. [366]

2.4.5.6 Intervention champion

An intervention champion is described to be a charismatic advocate of a program or intervention that provides an invaluable resource to gain and sustain momentum for innovative programs. [366] A champion spreads new ideas through social systems by expressing enthusiasm and confidence about the success of the intervention, by getting the right people involved and by persisting under adversity. [366, 367] Champions are described to act as gatekeepers for interventions, helping change social norms and accelerating behaviour change through the raising of awareness, the persuasion of others, the establishment or reinforcing of norms, and the leveraging of resources. [368] This process aligns well with the constructs of the SCT, particularly observational learning and reinforcement. [346] Given this, programs that use champions have been shown to be more effective than those that do not. [368]

Despite this known effectiveness of intervention champions, few studies have examined their use in technology-based interventions across the literature. Of the few studies applying similar concepts, an Australian study aiming to describe the experiences of parents (of children birth to 3 years of age; n=28) as peer educators disseminating nutrition and child feeding information via Facebook®, email, and printed resources for six months, reported that child feeding information was received as trustworthy and helpful (Appendix 4). [369] Newer parents were reported to be the most receptive to information for parenting peers, while family members were the least receptive. [369] This later finding is interesting since family members are commonly sighted as a key source of child feeding information. [278, 279] Information received verbally and via social media were preferred over print and email. [369]

In investigating this potential benefit of a technology-based intervention champion, attention must be given to selecting and training such champions. While champions can come from anywhere (e.g. community members through to celebrities), self-selection is likely to be the most practical way of identifying potential champions in a technology-based intervention. This method carries with it numerous advantages including cost-effectiveness, the development of credibility of the champion due to shared community membership, utilisation of effective leaders due to high interest and motivation, and the use of community appropriate language and expressions, thus making the message more effective than if they had come from non-peer researchers. [368] Howell and colleagues (2005) further detailed 14 items that can be used to identify champions and/or champion behaviour gaps which could be adapted to identify and appropriately train potential champions in technology based intervention. [367] Such training of champions for technology-based interventions is likely to include understanding of the role of a champion, appropriate resources to support understanding of intervention objectives and core messages, and training in communication etiquette as appropriate to the platforms in use. [368] Ongoing training and communication with researchers is further likely to be imperative, with much still to be learnt about how best to maximise the potential of intervention champions in technology-based interventions.

2.4.5.7 Data collection

Collecting quantitative data through technology based interventions follows similar principles to traditional, face-to-face data collection but often with less researcher burden as data do not need to be manually entered into statistical analysis software and re-coding can often be minimised. [354] However, for participants, technology-based data collection tools (e.g. online surveys) can be more restrictive than traditional, paper-based surveys thus consideration must be given to the needs of participants. For instance, participants are often prevented from skipping questions (through survey settings), or prevented from accessing the intervention tools based on their demographics, and while this approach may work in controlled laboratory settings, in an online context, it may trigger dishonest responses or increase dropout rates. [354] Resolving these issues for participants and screening the data after collection (rather than inhibiting it during collection), is consequently advised. [354]

While Facebook® can be used to simply redirect participants to online survey platforms, it can also offer the benefit of additional qualitative and quantitative data, and additional data collection tools. Qualitatively, participants written responses can provide a rich source of data, with screenshots of such artefacts offering a convenient means of recording and collecting such interactions for further detailed analysis. Quantitatively, Facebook® *Insights* also provide extensive data reflecting participant engagement with *posts* (*reach,* demographics, times/day of engagement, type of engagement), that can be downloaded and exported. This feature is particularly useful for researchers in analysing engagement, fidelity, and evaluating participant satisfaction/interest. Further to this, *polling* tools and *reactions* (e.g. likes/dislike, emoticons/ emojis) within Facebook® can also be used to gauge satisfaction, compliance with intervention protocol, or simply boost participant engagement.

With these benefits in mind, to fully tap into the research potential offered by Facebook® and other technology based platforms, such as websites, researchers need to rethink traditional research designs and acquire new skills, including more advanced statistical techniques, and an understanding of Facebook® etiquette, lingo and jargon. [354]

2.5 Discussion

The literature reviewed throughout chapter 2 provided a thorough view of the relationship between children's eating behaviours, obesity status and FFE's as well as the potential to modify FFE's to reduce obesity risk via eating behaviours. In this regard, the literature reviewed provided preliminary identification of modifiable factors and potentially mediating variables in childhood obesity in accordance with the first two components in the 4-component planning health interventions process (figure 4).

Specifically, section 2.1 examined the relationship between children's eating behaviours and obesity status to suggest that deviations in eating behaviours during early childhood (e.g. increased food approach eating behaviours and/or reduced food avoidance eating behaviours, such that energy homeostasis is not maintained) are likely to precede obesity development. [58-60, 63] While the limited number of prospective studies, and studies with adequate sample size, during the years of early childhood makes these results far from conclusive, the prospect of this relationship supports that early childhood is a prime period to 'protect' innate eating behaviours and/or reduce deviations in eating behaviours that increase the risk of obesity.

Section 2.2 builds on this by examining underpinning appetite mechanisms to suggest that early life influences may contribute to deviations in eating behaviours that increase obesity risk. [75, 94, 141, 149] Disadvantage related pathways (reflected in variables such as single-parent status, lower maternal education, lower family income, income insufficiency) appear to be particularly important modifiers of eating behaviours in early life and thus children in these circumstances may be more prone to deviations in eating behaviours and/or be limited in their ability to respond effectively to intervention. [63, 141, 149, 180] Much, however, remains unknown in this regard, with few studies examining relationships between eating behaviours and psycho-social variables and even fewer examining differences in the malleability of eating behaviours through intervention. While Dubois, et al., (2007), and Albuquerque, et al., (2017), are among the few researchers to have examined the relationship between eating behaviours and psycho-social variables, the results produced are limited as the breadth of eating behaviours associated with obesity were not explored. [63, 180] Building understanding of these relationships may assist in explaining differing rates of obesity within the population, in determining opportunities for targeted obesity prevention initiatives, and in identifying population groups that may be resistant to intervention effects.

Moving beyond intrapersonal factors, section 2.3 examined the relationship between FFE variables, children's eating behaviours and obesity status. While it is acknowledged that bi-directional relationships likely exist between these variables, as specifically discussed in section 2.3.3, for the purpose of obesity prevention interventions, focusing attention on the modifiable parent-driven associations is a logical approach given the important role parents play as gatekeepers of the FFE. Parent's feeding practices and strategies were specifically highlighted as showing evidence of bi-directional relationships, however, variations in measurement tools and conceptualisation of restrictive feeding practices (overt verse covert restriction) has led to inconsistent results that require further investigation. [243-245, 259, 260, 263]

Further to this, current understanding of FFE's in relation to children's eating behaviours is fragmented, with studies largely focusing on a few select variables which fails to reflect the authentic interactions and ecological exposures experienced by children (table 3). Additionally, understanding within this area of research is limited due to much of the evidence derived being based on analysis from a limited number of cohort samples (as discussed in section 2.3.3). Given this, research is needed that examines the collective influence of FFE variables on children's eating behaviours and obesity status (from diverse samples) as well as exploration of potential mediator relationships, as theorized within the behavioural susceptibility theory. [2] Focusing future research on the role of children's eating behaviours as intermediaries in the relationship between FFE's and obesity status will assist to justify the use of children's eating behaviours as surrogate endpoints in obesity prevention interventions, while examining the collective relationship of FFE variables with children's eating behaviours and obesity status will provide a comprehensive perspective from which to plan appropriately targeted multicomponent interventions (section 2.3.3 for further gaps identified in current FFE literature). This focus of interventions on eating behaviours as a surrogate endpoint is theorised to be advantageous, as detecting changes in these variables is expected to be possible within a shorter time period than detecting differences in child weight.

In regards to intervention planning, section 2.4 summarized the literature in relation to the effectiveness of current obesity prevention interventions. Although few studies have focused on children's eating behaviours as an outcome, results from the NOURISH RCT support the potential for children's eating behaviours to be 'protected' (from deviations) through intervention, although evidence is yet to show if such 'protection' translates into reduced obesity development. [307] While this appears to be a promising area for future research, additional information about the relationship between FFE's, children's eating behaviours and obesity status are needed to better understand how these variables interact, as critical to accurately inform how best to direct future intervention protocols. In addition to the gaps identified in understanding of these relationships, in order to progress this area of future research, additional information is also needed in relation to how best to delivery such interventions. While technology-based interventions are emerging as one such way to efficiently and effectively deliver interventions, evidence supporting parent's willingness to engage with such methods is lacking. Conducting research to determine parent's willingness to engage with interventions is consistent with the concept of community consultation, as the process of working collaboratively with groups of people affiliated with respect to issues affecting their well-being, and is considered key in developing interventions that are readily adopted by the target community. [370] Consequently, failure to consider parent's acceptability towards intervention design, key messages, and modes of intervention delivery is likely to impede on the overall impact and effectiveness of an intervention. Conversely, increasing researchers understanding of parent's acceptability towards child feeding intervention protocols will allow more appropriately designed interventions, that are likely to have higher rates of engagement, adherence, and consequently, outcome success. [343, 346, 347, 349, 371]

Overall, addressing gaps identified in the literature reviewed throughout chapter 2 is necessary to better inform and target public health initiatives aimed at reducing obesity in early childhood, promoting eating behaviours that are conducive with positive health outcomes, and supporting parents to create comprehensively healthful FFEs. Additionally, while gaining understanding of these potentially modifiable and mediating variables in childhood obesity is important in informing future intervention opportunities, determining parent's willingness to participate in interventions designed to actively modify the FFE, is equally important. Consideration needs to be given to how to reach more diverse populations of Australian parents and overcome current issues related to homogenous samples (section 2.3.3). Use of the internet poses much potential in this area, as identified to be a common source of nutrition knowledge and information among parents and as an important digital resource within the homes of Australian children.

Table 5: Key gaps and limitation identified in the literature	
To be addressed in this thesis	**To be addressed in future research**
Section 2.2 – Intrapersonal variables related to children's eating behaviours	
	• Longitudinal exploration of the relationship between appetite/eating behaviours and obesity from early childhood and across the life course is needed to better understand changes that occur and may influence obesity development.
Section 2.3 – Family food environment variables	
• Additional studies with a diversity of participants	• Longitudinal and prospective studies are needed

is needed to overcome homogenous samples used in Australian and international research. • Fathers are underrepresented in the literature. Additional studies are needed which include fathers. • Studies are needed that explore the relationship between FFE variables collectively and children's eating behaviours and weight status to provide an authentic reflection of ecological exposure, controlling for intrapersonal factors. • Additional research is needed into the distinct roles of overt and covert restriction on children's eating behaviours and weight status. • The potential for mediator relationship between FFE, children's eating behaviours and obesity status needs exploration such as to statistically support the behavioural susceptibility theory. • Much remains unknown about micro-environment variables within FFE's in Australia.	to gain further understanding of relationships between FFE's, eating behaviours and weight status during early childhood, and the directions of these relationships.
Section 2.4 – Modification of eating behaviours & intervention opportunities	
• Research is needed to determine how best to deliver interventions to a diversity of participants (in order to overcome homogenous samples), in consideration of parent's willingness and acceptability towards intervention design and messages such as to maximise behaviour change potential.	• Research is needed to determine the feasibility of modifying appetite/eating behaviours, particularly in children who are 'at risk' of deviations in eating behaviours (e.g. genetically susceptible and disadvantaged circumstance).

The gaps identified in the literature, as discussed in section 2.5, have been used to guide development of the specific research aims presented in chapter 3. Although opportunities for future research in this area would benefit from longitudinal analysis, this is beyond the scope of this PhD.

Figure 5: Thesis mapping schematic model – Chapter 3

4-component process [45, 46]	**Capacity building stages** [50]		**Thesis chapter 3 key points**
1. Identification of modifiable factors which could be target behaviours ***2. Identification of potential mediators*** ***3. Selection and justification of theoretical model***	**Assessment**	Define needs and analyses problem	**Chapter 1: Introduction** • Childhood obesity major public health issue • Family food environments are the central context in which early childhood obesity emerges **Chapter 2: Literature review** • Children's eating behaviours associated with child weight status • Family food environments provide a key context in which childhood obesity develops through interactions with eating behaviours • Family food environments offer opportunity for intervention directed towards eating behaviours and obesity development • The social cognitive theory (SCT) and health belief model (HBM) provide a suitable framework for intervention planning • Technology offers new opportunity for intervention delivery
	Analysis	Determinant analysis	**Chapter 3: Methods** **3.1 Aims:** 1. The relationship between children's eating behaviours & BMI, controlling for psycho-social variables; 2. A descriptive picture of FFE in early childhood in Australia 3. The intermediary role of children's eating behaviours in the relationship between FFE & child BMIz, 4. The collective influence of FFE variables on child eating behaviours & BMI 5. Parent's acceptability towards child feeding intervention opportunities 3.2 Survey 1: Eating behaviours & family food environment 3.3 Survey 2: Intervention opportunities & acceptability **Chapter 4: Results** 4.1 Survey 1
6. Design intervention	**Action**	Explore strategy options	4.2 Survey 2 - Intervention opportunity & acceptability survey
	Assessment	Implement the strategy portfolio & evaluation (Planning only)	**Chapter 5: Future direction & conclusion** 5.1 Overall discussion 5.2 Recommendations for intervention design

3.1 Aims and research questions

Overall this thesis aimed to explore the relationship between FFE variables and children's eating behaviours and obesity status in early childhood in Australia, with the explicit intent of using this understanding to propose an early childhood feeding intervention.

Aim 1: To examine the relationship between children's eating behaviours & BMIz, controlling for psycho-social variables.

To determine psycho-social variables (income status, single-parent status, sleep duration, parent's depression, stress and anxiety, and breastfeeding duration) associated with children's eating behaviours and the relationship these behaviours have with BMIz in Australian children during early childhood (2.0 – 5.0 years).

Addressing this aim may assist in explaining inequitable distributions of obesity seen across the population and support understanding of the potential to protect children's eating behaviours as a focus for future obesity prevention interventions.

Aim 2: To develop a descriptive picture of family food environments in early childhood in Australia.

To provide broad scoping descriptive data reflecting the FFE of Australian children during early childhood (2.0 – 5.0 years), as conceptualised within the socio-ecological model, and to extend on what is currently understood about the relationship between FFE variables and children's eating behaviours.

A more thorough *picture* of ecological exposure during early childhood in Australia and the relationship this environment has with children's eating behaviours, is of value in informing health promotion initiatives, in supporting parents in creating health promoting FFE, and in manage difficult eating behaviours during early childhood. Specific attention has been given to the distinct roles of overt and covert restriction in these relationships.

Aim 3: To examine the intermediary role of children's eating behaviours in the relationship between family food environments and child BMIz.

To statistically examine the intermediary role of children's eating behaviours with child (2.0 – 5.0 years) BMIz in accordance with the behavioural susceptibility theory.

Determining the intermediary role of children's eating behaviours in child weight status adds support for such behaviours as an outcome focus for obesity prevention interventions.

Aim 4: To examine the relationship between collective factors of family food environment variables with child eating behaviours and BMI categories.

To examine the relationship between collective factors of FFE variables on children's eating behaviours and BMI categories, as a more authentic reflection of ecological exposure during early childhood (2.0 – 5.0 years) in Australia.

Highlighting FFE variables that appear to group together offers a novel perspective from which to further examine relationships with children's eating behaviours and obesity status. Additionally, since psycho-social factors such as income, parental marital status, parental depression, anxiety and stress, and parent's BMI, are likely to have a distinct relationship with the FFE factors constructed, relationships between these co-variates and factors of FFE required examination. Such differences in FFE's are also likely to contribute to explanations of inequitable distributions of obesity across the population and support appropriately targeted intervention initiatives.

Aim 5: To examine parent's acceptability towards child feeding intervention opportunities.

To determine parent's (of young children; 2.0 – 5.0 years) acceptability towards, and behaviour change intentions within, a child feeding intervention, with consideration explicitly given towards acceptability of online modes of intervention delivery as a plausible means to reach a diverse sample of participants.

While answering research questions 1 - 4 provides important information in understanding the relationship between FFE variables, children's eating behaviours and obesity status, for this understanding to translate into meaningful public health action it is necessary to determine parent's willingness to participate in child feeding interventions. Furthermore, given the need to reach a diversity of participants, exploring the potential of internet-based technologies to deliver such an intervention is advantageous in translating this research into public health action. The method of answering this research question (survey 2) is detailed in section 3.3.

3.2 Survey 1 method

To address research questions 1 – 4, a cross-sectional, online survey (survey 1) was conducted with Australian parents of children aged 2.0 – 5.0 years. The data collected from this survey were used to establish relationships between children's eating behaviours, FFE variable and weight status with the intention of identifying potentially modifiable and mediating variables that could be targeted in future obesity prevention interventions, in accordance with the first two components in the 4-component process in planning health intervention (figure 5).

3.2.1 Sample size

To produce an outcome that was likely to be of both clinical significance and statistical significance, a sample of at least 130 participants was deemed necessary to address research aims 1 - 4. This sample size was determined using the data published by Webber and colleagues in 2009. [5] These works found significant differences in several CEBQ sub-scale scores when their cohort of 406 children were divided into underweight, healthy weight, overweight and obese categories based upon BMI. Using the difference in CEBQ sub-scales reported for healthy weight and overweight and a pooled standard deviation of these sub-scales, standard sample size calculations were undertaken to determine the sample size needed to be able to show significance at 5% with a power of 80% if the differences reported by Webber et, al. (2009) were found in the cohort recruited for this current study. Those numbers are shown in table 6 below.

Table 6: Sample size calculations

CEBQ sub scales	Difference between health weight and overweight groups in Webber et al (2009)	Pooled SD	F= diff/DS	N= $16/f^2$
Food Responsiveness	**0.55**	**0.815**	**0.67**	**35**
Emotional Overeating	0.37	0.68	0.54	55
Enjoyment of food	**0**	**0.085**	**0**	**0**
Desire to drink	0.25	0.94	0.26	231
Satiety Responsiveness/ Slowness in eating	**-0.25**	**0.62**	**-0.4**	**100**
Emotional Undereating	0.09	0.74	0.12	1600
Food Fussiness	**-0.29 (girls)** **0.05 (boys)**	**0.125 (g)** **0.135 (b)**	**-2.32** **0.37**	**3** **123**

Clearly a sample size of 1600 needed to show significance between sub-scale scores for "emotional undereating" was unlikely feasible within the context of a PhD, however, a sample size of 123 would allow significance to be detected between healthy weight and overweight sub-scale scores for food fussiness. It should be noted that only the sub-scales in bold were selected for use in this thesis, as per Fildes, et al., (2015; section 3.2.4.1), thus the sample size required to detect significance in the 'desire to drink' sub-scale was not selected. [67]

3.2.2 Ethics

Ethical approval for this survey (survey 1) was granted through The University of Queensland (approval number 2016000860) in June 2016.

3.2.3 Data collection

Between July and November 2016, Australian parents of children aged 2.0 – 5.0 years self-enrolled to complete an online, cross sectional survey. Participants were invited to enrol in the survey through advertising on the social media website Facebook®. The advertisement provided brief information about the survey and provided a link to a Weebly® website which contained further details about the research project as well as a plain language statement, participant consent form, and access to the online survey hosted by Checkbox®. No incentives were provided for participation in the survey. For parents with more than one child within the target age, parents were asked to refer to the child whose birthday occurred next.

3.2.3.1 Facebook® recruiting

Given the popularity of Facebook®, as a digital home resource accessed by a diversity of parents with young children, as discussed in section 2.3.2.2, Facebook® was used as the exclusive recruitment platform for survey 1. The following section describes the recruitment process utilised. The distinct benefits of Facebook® as a recruitment platform have been discussed in section 2.4.5.

3.2.3.2 The process

In utilising Facebook® to recruit participants in survey 1, three 'gatekeeper' pages as well as a 'host' Facebook® page were used to display advertising material. The gatekeeper pages included conveniently selected pages managed by organisations and bloggers targeting an audience of Australian parents of children in early childhood (Family Magazines Brisbane, ACT Playgroup Association, Modern Father Online), while the 'host' page was a pre-existing Facebook® page managed by the researcher (The Kids Menu) which similarly targeted an audience of Australian parents (current audience comprises n=3646 Australian parents, 95% female, 5% male). Data on the demographics of users of these sites was not available and as such it was not possible to determine if users of these sites are representative of the general population.

The ‘gatekeeper’ and ‘host’ pages posted a short blurb, along with a web link, inviting participants to complete the online survey about children’s eating behaviours and the FFE.

Figure 6: Family Food Environment Survey Advertisement

Screenshot of Family Food Environment Survey advertised through Facebook®

3.2.3.3 Sponsored posts (Facebook® advertising)

To assist in recruiting an advertising budget was applied to the Facebook® post from the ‘host’ page and an audience specified within Facebook’s® ‘advertisement manager’ settings. In this instance, the budget was initially set at $60 (AU), as sufficient according to Facebook® algorithms to reach 2100 – 5,500 Facebook® users based on the selected audience of Australians aged between 18 and 45 with interests in: motherhood, single parents, fatherhood, preschool, husband, parenting, kindergarten, parent, childhood, toddler or family. This ‘sponsored’ post resulted in the recruitment of 148 participants within the target audience (from a total ‘reach’ of 15,682 on the host site; 4,483 ‘organic,’ being directly from the post on the host page and 11,199 ‘paid’ from the $60 advertising budget. Similar data is not available from the gatekeeper sites). Based on this return, an additional $400 dollars was applied to the ‘sponsored’ post which ultimately resulted in 1296 participants entering this study (out of 107, 972 potential participants ‘reached’). The recruitment period for this study was set based on maximum return from the advertising budget according to Facebook® advertising manager.

3.2.4 Survey measures

As guided by the literature, the range of FFE variables that showed relationship with children's eating behaviours or obesity status, as conceptualised within the socio-ecological model (interpersonal and micro-environment levels), were included in this survey. Where possible pre-validated survey measures were used and where such instruments were not available, questions were developed as guided by the literature. In addition to this, parents were asked to identify if their child had a medical condition affecting their growth, development or metabolism, and children were excluded from participating in this study based on this response. The survey was piloted in a convenience sample of parents with young children.

A total of 111 questions were included.

The survey collected:

- Parent-reported anthropometric data for parent and child (weight and height),
- Responding parent's and reference child's sex,
- Parent-reported response to inclusion/exclusion criteria,
- Child age, to the nearest half year,
- Demographic data (income [less than $40,000; $40,000 - $100,000; More than $100,000], family structure [single parent or other], breastfeeding duration [No, never breastfed; Yes, for less than 3 months; Yes, for between 3 and 6 months; Yes, for between 6 and 12 months; Yes, for more than 12 months], number of children in the home [continuous], state of residency [categorical], and region of residence [categorical response based on rural, remote and metropolitan areas (RRMA) classification]), [372]
- Children's eating behaviour data via the child eating behaviour questionnaire (CEBQ) sub-scales as per Fildes, et al., (2015), [35, 67]
- Parent feeding strategies, parenting dimensions and meal structure data via the feeding practices and structure questionnaire (FPSQ-28) as per Jansen, et al., (2014 and 2016), [243, 244]
- Data on the use of TV/electronic devices during meals,
- Data on the frequency of family meals per week,
- Data on parent's depression, anxiety and stress levels via the depression, anxiety and stress scale (DASS-21) as per Szabo (2010), [373]

- Data on parent's personal skills via questions adapted from Parmenter, et al., (1999), General Knowledge Questionnaire, [374]
- Data on kitchen scape (e.g. sufficiency of the kitchen for food preparation and food storage) and home resources (e.g. sufficient money to buy food, availability of fruit and vegetables),

See Appendix 5 for full survey.

3.2.4.1 Children's eating behaviour questionnaire (CEBQ)

The CEBQ is a 35-item tool designed to assess children's eating behaviours. The CEBQ has eight sub-scales in total, but only five were used in survey 1: enjoyment of food (4 items); food responsiveness (5 items); satiety responsiveness (5 items); slowness in eating (4 items); and food fussiness (6 items). The reduced number of sub-scales included in survey 1 aimed to minimise participant burden and was consistent with the sub-scales used by Fildes, et al., (2015). [67] Scoring methodology was further guided by Fildes, et al., (2015) such that items were scored on a 5-point scale, with higher scores indicating higher values of each trait. [67] The CEBQ has previously shown good psychometric properties (e.g. concurrent validity, internal consistency and test-retest reliability) and has been validated in a group of first time Australian mothers with children 2 years of age (i.e. the factor structured was confirmed and all subscales showed good internal reliability with Cronbach's alpha values between .73 to .91). [179, 243] This sample population was further used as a control group to validate the CEBQ within two other ethnically and culturally diverse samples of mothers in Australia (immigrant Indian mothers of children aged 1 – 5 year and immigrant Chinese mothers of children aged 1 – 4 years), with Cronbach's α estimates ranging from 0.61– 0.88 in the immigrant samples. [179] Given such internal reliability, validation across culturally diverse samples and wide use across the literature which supports comparability of findings the CEBQ was deemed suitable for the purposes of this research.

3.2.4.2 Feeding and practice structure questionnaire (FPSQ-28)

Parent feeding practices and structure were measured using the FPSQ-28, developed by Jensen, et al., (2016). [244] This version of the FPSQ was selected to reduce participant burden while still capturing the essence of the original 40 item FPSQ. [243] That is, the FPSQ comprises a number of feeding practice scales that assess conceptually distinct dimensions of responsive feeding (practices that support children's self-regulation of intake) and appropriate structure and limits (practices that create an environment supportive of healthy eating), in an attempt to capture both parenting styles and practices as well as feeding strategies. [243] The development of the FPSQ was specifically focused on capturing the key components of 'authoritative feeding' as associated with the development of healthy eating patterns and favourable BMI outcome (consequently a separate parenting style questionnaire has been omitted from the proposed survey). [239, 243, 375, 376] The FPSQ also aimed to capture both overt restriction and covert restriction, as discussed to be a likely important distinction in restrictive feeding practices that is currently under-explored in the literature.

Similarly to the FPSQ, the FPSQ-28 has shown good psychometric properties in a sample of Australian mothers of children aged 2, 3.7, and 5 years; reward for behaviour (4 items, Cronbach α .79 - .80); reward for eating (4 items, Cronbach α .84 - .86); persuasive feeding (6 items, Cronbach α .73 - .77); overt restriction (4 items; Cronbach α .61 - .68); covert restriction (4 items, Cronbach α .78 - .80); structured meal setting (3 items, Cronbach α .68 - .75); structural meal timing (3 items, Cronbach α .57 - .70). [244] As per the FPSQ, scores for the FPSQ-28 are allocated from 1 – 5, with higher scores indicating greater endorsement of the relevant factor. [244]

3.2.4.3 Use of television and electronic devices

To establish the use of TV and/or electronic devices during meals, such as tablets (e.g. iPad®), smartphones or other handheld devices, three items were developed and scored as follows: 1. Is the TV viewed by the family during meals? [Yes/ No/ Sometimes]; 2. Are devices [phones, iPad®, etc.] use by children during meals? [Yes/ No/ Sometimes]; 3. Are devices [phones, iPad®, etc.] used by adults during meals? [Yes/ No/ Sometimes]). Items were retained for analysis as categorical variables.

3.2.4.4 The frequency of family meals

The frequency of family meals per week was captured according to parent's responses to the item 'How many meals are eaten with all families present per week?' A maximum score of 21 was possible for this item (score for breakfast 0 – 7, lunch 0 – 7 and dinner 0 – 7). A greater score indicated more meals eaten together.

3.2.4.5 Parent's depression, anxiety and stress (DASS-21)

Parental depression, anxiety and stress were measured using the DASS-21, as a self-report questionnaire designed to measure the severity of a range of symptoms common to depression, anxiety and stress. [377] Both the original 42-item and the shortened 21-item DASS have been shown in a large body of literature to be a reliable and valid measure of depression, anxiety and tension/stress in clinical and non-clinical populations of adults. [373] The DASS-21, collects data of symptoms of depression, anxiety and stress over the previous week and scores them from 0 (did not apply to me at all over the last week) to 3 (applied to me very much or most of the time over the past week). [377]

3.2.4.6 Parent's personal skills

Parent's nutrition knowledge was measured using questions adapted from the works of Parmenter, et al., (1999), as contextually appropriate to Australian parents of children during early childhood (e.g. in accordance with relevant Australian Dietary Guideline materials). Parmenter, et al., (1999) recommends four areas underlie the main aspects of instruments relating to knowledge of dietary behaviour: Do people know what current expert dietary recommendations are? Do they know which foods provide the nutrients referred to in the recommendations? Can they choose between different foods to identify the healthiest ones? And, do they know what the health implications of eating or failing to eat particular foods are? [374] Although a General Knowledge Questionnaire, based on the works and recommendations of Parmenter, et al., (1999), has been developed and validated within Australia, as this tool contains 113 items (knowledge of dietary recommendations (13 items), sources of nutrients (70 items), choosing everyday foods (10 items) and the diet–disease relationships (20 items)), it was considered too burdensome for survey 1 and as such a shorter version, informed by the literature, containing 5 items (knowledge of dietary recommendations of children [2 items; max 2 points], sources of nutrients [1 items, max 1 point], choosing everyday foods [1 items; max 5 points] and the diet–disease relationships [1 item; max score 5]), was developed. [378] Items were binary coded and scored as either correct (1) or incorrect (0), to produce a total score out of 13, with a higher score indicating better general knowledge.

Further to this, parents were also asked to categorically identify sources of nutrition information and knowledge from a list of 10 common sources (e.g. internet, friends, Australian Dietary Guidelines, doctors, etc.). Four questions were also developed to capture parent's attitudes and beliefs related to food and nutrition. Parents responded to the statements ‘Eating healthy is expensive,’ ‘It takes too long to prepare a healthy meal,’ ‘Healthy food doesn’t taste good,’ and ‘Nutrition is important to your family’ [reverse scored], on a four-point scale, with a higher score similar indicating more negative attitudes and beliefs. Items were devised based on key barriers to healthy eating qualitatively themed from a sample of Australian adults and phrased as a belief by assigning attributes to identified barriers towards healthy eating. [379, 380] Each item was scored individually as a categorical variable, as well as combined to create a continuous total nutrition related belief score.

3.2.4.7 Home resources

Nine final items were included in survey 1 regarding kitchen-scape and home resources. As no validated instruments reflecting this area of interest were identified, questions were developed to gain understand of the suitability of cooking facilities, food storage (fridge, freezer, pantry), sufficient money to purchase food each week, availability of fruit and vegetable within the home, and in-home resources such as cooking and shopping skills. These items were scored from 1 – 4 or scored with a nominal scale. Parents were also asked to categorically identify who was responsible for grocery shopping and meal preparation within the home.

3.2.5 Data analysis and cleaning

3.2.5.1 Child anthropometric data

Child height, weight and BMIz were calculated according to the 2000 CDC growth charts. [381] Use of CDC growth charts for children from 2 years of age is consistent with the recommendations of the National Health and Medical Research Council (NHMRC). [17]

As height and weight data in these works were by parental report it was considered that they may not be associated with the same degree of accuracy that would be found in a clinical research setting. It was therefore important to screen these data for what is often called biologically implausible values. There is no standard approach to assessing biologically implausible values and a recent review found 11 different approaches in the literature since the year 2000. [382] Lawman and colleagues also reported that of the large epidemiological studies found by their literature search, approximately 41% did not address biologically implausible value identification at all. No recommendations were made in relation to any one approach over any other method in this paper. [382]

The approach taken in this thesis to identify biologically implausible values involved creation of a 'modified Z score.' This method was suggested by the CDC since using the CDC BMI reference data to calculate BMIz that are then screened for biologically implausible values will lead to errors since, when constructing the CDC growth charts, Cole's LMS method was not followed exactly, as described below. [383]

Most growth references are now calculated using Cole's LMS method. [384] This method summarises the distribution of anthropometric data at any given age and for each gender in just three variables; L, M and S. The LMS parameters are the power in a Box-Cox transformation that normalises the distribution (L), the median (M) and the generalised coefficient of variation (S). Using these parameters any desired centile and z-scores can be calculated. In the LMS method, the LMS parameters are estimated from the data, then smoothed and then used to create centiles. When constructing the CDC growth charts this approach was not followed exactly and instead the required centiles were estimated from the data, then smoothed and used to calculate the LMS parameters; a subtle but important difference. The outcome of this difference in approach means that the LMS values produced in this way are not good at determining z-scores of extreme data points, and therefore for screening for biologically implausible values.

Despite attempting to alleviate this problem, it should be noted, however, that the calculation of a "modified z-score" is not universally supported (Cole TJ, personal communication 2017), as it uses arbitrary z-scores in its calculation and introduces asymmetry into the screening process with less variability below the median than above. Bearing this in mind, it was chosen, therefore, to screen for biologically implausible values using a two-step approach. Firstly, all weight or height z-scores greater or less than 3 were discarded. Secondly, after regressing weight z-score on height z-score any residuals greater or less than 2.5 were also discarded.

3.2.5.2 Parent BMI

Parent's self-reported weight and height were used to calculated BMI scores and BMI categories in accordance with the World Health Organizations classifications (Underweight <18.50kg/m2; Normal weight 18.50 – 24.99kg/m2; Overweight ≥25.00kg/m2; Obese ≥30.00kg/m2). [385] Parent's BMI were initially visually screened for very high or very low values, as considered to be biologically implausible.

3.2.5.3 Children's eating behaviour questionnaire (CEBQ) sub-scales

Mean scores for each of the CEBQ sub-scales were created. Each sub-scale showed acceptable internal reliability, except slowness in eating, which was slightly below that desired Cronbach α 0.7; enjoyment of food (4 items; Cronbach α 0.866); food responsiveness (5 items; Cronbach α 0.786); satiety responsiveness (5 items; Cronbach α 0.705); slowness in eating (4 items; Cronbach α 0.676); and food fussiness (6 items; Cronbach α 0.923). [386, 387] CEBQ sub-scales were normally distributed (skewness and kurtosis between 1 and -1).

3.2.5.4 Depression, anxiety and stress scale (DASS-21)

Mean scores for the parent's depression, anxiety and stress scales were created. Mean scores for each scale showed high internal reliability; stress [7 items; Cronbach α 0.837] anxiety [7 item; Cronbach α 0.742] depression [7 items; Cronbach α 0.886]. Each DASS scale was examined for normality (skewness and kurtosis between 1 and -1). Depression and anxiety scales were deemed skewed so transformed accordingly, however, the stress scale was normally distributed.

3.2.5.5 Feeding practice and structure questionnaire (FPSQ-28)

Mean scores for each of the 8 FPSQ-28 sub-scales were created. Of the scales reported in this study, only 5 scales showed acceptable internal reliability, based on Cronbach α 0.7 (reward for behaviour [4 items; Cronbach α 0.821], reward for eating [4 items; Cronbach α 0.762], persuasive feeding [6 item; Cronbach α 0.802], covert restriction [4 items; Cronbach α 0.808], structured meal setting [3 items; Cronbach α 0.865]. Overt restriction showed questionable internal reliability [4 items; Cronbach α 0.604], and removal of items did not improve reliability. Similarly, structured meal timing showed questionable internal reliability [3 items; Cronbach α 0.670], and removal of items did not improve reliability. Family meal setting was also included as a single item as recommended by Jansen, et, al (2016). [244] These findings were, however, consistent with the Cronbach α reported in FPSQ-28 validation studies. [244] All scales were deemed to be normally distributed (skewness and kurtosis between 1 and -1).

3.2.5.6 TV and electronic device use

The three items reflecting TV and electronic device use during meals showed below acceptable internal reliability (Cronbach's α 0.457) and therefore were retained as three categorical items.

3.2.5.7 Frequency of family meals

The three items measuring the frequency of family meals showed less than acceptable internal reliability (Cronbach's α 0.527). A total frequency of family meals score was created (out of 21) and was deemed to be normally distributed (skewness and kurtosis between 1 and -1).

3.2.5.8 General nutrition knowledge

General nutrition knowledge data were used to create a total nutrition knowledge score and knowledge sub-scores. Internal reliability for total nutrition knowledge was less than acceptable (Kuder-Richardson-20, as a dichotomous alternative to Cronbach's alpha measure of reliability, reached 0.347, 13 items). Each of the sub-scores also had low internal reliability (heart disease, Cronbach's α 0.407, 5 items; high/low salt, Cronbach's α 0.194, 5 items; knowledge of dietary guidelines, Cronbach's α 0.271, 3 items). Scores for total nutrition knowledge, as considered a continuous 13-item scale, were skewed so transformed accordingly.

3.2.5.9 Nutrition-related belief

Although each of the nutrition related beliefs were intended to be used as an individual scale, they appeared to have internal reliability only slightly below acceptable (Cronbach's α 0.573). This level of reliability is, however, not unexpected given that the scale included only four items and Cronbach's alpha is understood to increase as the number of items on a scale increase. The combined total nutrition-related belief scales, compiling all four belief items was deemed to be normally distributed (skewness and kurtosis between 1 and -1). In addition to a total nutrition belief scales, all individual beliefs were retained as ordinal variables.

3.2.5.10 Home resources

All other items (e.g. cooking skills, shopping skills, availability fruit and vegetables, cooking facilities, food storage facilities, responsibility for food purchasing, responsibility for meal preparation) were retained as categorical variables.

3.3 Survey 2 method

Given the potential of technology-based interventions in overcoming many burdens of traditional interventions and the high importance of community engagement in intervention development, this section addressed aim 5 of this thesis (section 3.1) by; 1) identifying parent's child feeding concerns and behavioral motivations as relevant to the development of future child feeding interventions, and 2) determining parent's willingness to participate in internet and social media based interventions. Consideration has been specifically given to issues such as social-desirability bias and participants concerns for privacy, as likely to be distinctly unique to technology-based interventions (section 2.4). The findings of this section are of benefit in the planning and delivery of future early child feeding interventions in Australia.

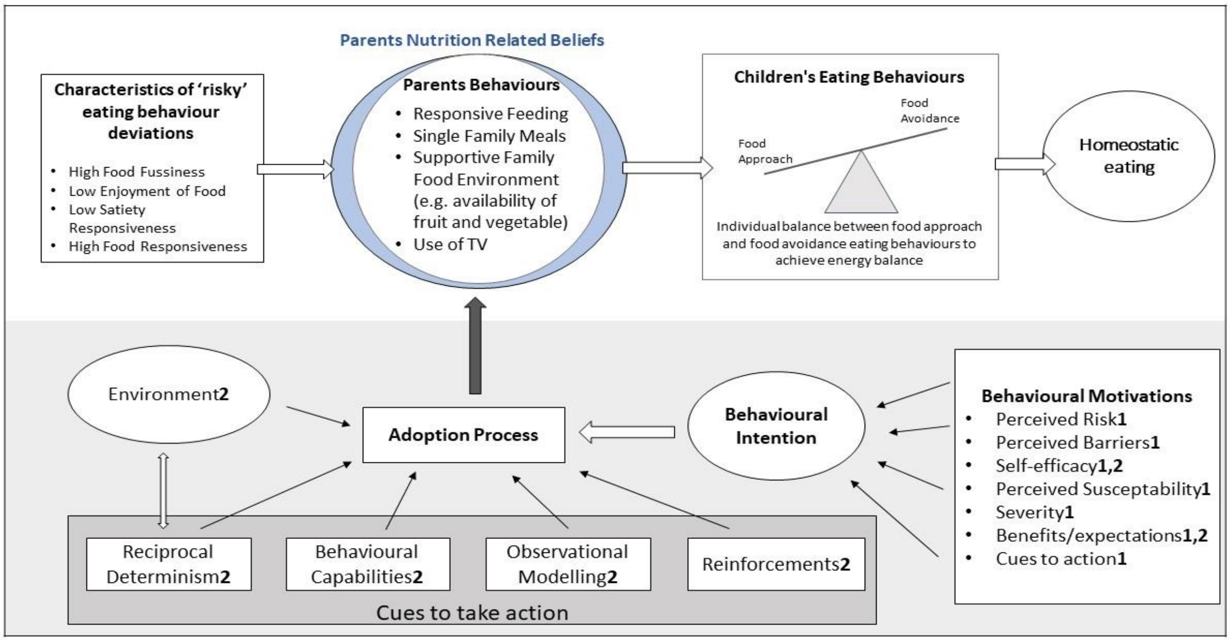
3.3.1 Intervention schematic model and intervention mapping

As informed by the literature reviewed in chapter 2, an intervention that aims to effect change within FFE by modifying parent's behaviours and beliefs, such that parents implement more responsive feeding practices, are supported in developing food utilisation skills, and are guided in altering underpinning nutrition related beliefs, is likely to create FFEs that encourage children to appropriately balance food approach and food avoidance eating behaviours such that energy homeostasis can be maintained, consequently, reducing the risk of obesity. In this regard, the following schematic model (figure 7) has been developed to depict theoretical pathways through which relevant intervention objectives could be achieve. This model is in accordance with the HBM and SCT (section 2.4.4), as were identified as appropriate theoretical models in understanding behaviour motivations and actions which in turn can be used to guide relevant intervention strategies and behaviour change techniques within the 'adoption process' of the model. Specific strategies and behaviour change techniques are discussed in section 5.2.

The schematic model indicates an appropriate balance of food approach and food avoidance eating behaviours such that energy homeostasis can be achieved is an appropriate 'surrogate endpoint' that is likely to indicate a reduced risk of obesity development. The schematic model also represents the relationship between parent's behaviours and beliefs within the context of the FFE, as modifiable and mediating factors in early childhood obesity status. The theoretical constructs of HBM and SCT from which an intervention has been designed (section 2.4.4), were also depicted. Combining the

HBM and SCT provides a thorough theoretical framework to understand both motivating constructs of behaviours (HBM), as well as constructs related to behaviour execution and action (SCT). [346-349]

Figure 7: Schematic model of behavioural motivations and behaviour change intentions aligning with the constructs of the HBM (1) and SCT (2)



1. Constructs of the HMB; 2. Constructs of the SCT; *Adapted from the works of Uesugi, et al. (2016)*

3.3.2 Ethics

Ethical approval for this survey (survey 2) was granted through The University of Queensland (approval number 2017001504).

3.3.3 Data collection

Between November 2017 and January 2018, Australian parents of children aged 2.0 – 5.0 years self-enrolled to complete an online, cross sectional survey. Participants were invited to enrol in the survey through advertising on the social media website Facebook®. The advertisement provided brief information about the survey and provided a link to a Weebly® website which contained further details about the research project as well as the plain language statement, participant consent form, and access to the online survey, hosted by Checkbox®. No incentives were provided for participation in the survey. For parents with more than one child within the target age, parents were asked to refer to the child whose birthday occurred next.

3.3.3.1 Facebook® recruiting

Given the popularity of Facebook®, as a digital home resource accessed by a diversity of parents with young children, as discussed in section 2.3.2.2, Facebook® was used as the exclusive recruitment platform for survey 2. The following section describes the recruitment process utilised. The distinct benefits of Facebook® as a recruitment platform were discussed in section 2.4.5.

3.3.3.2 The process

A 'host' Facebook® page was used to display advertise material used to recruit participants into the survey, as consistent with the method used in survey 1, described in section 3.2.3.2. Gatekeeper pages were not used to assist in recruiting in survey 2.

3.3.3.3 Sponsored posts (Facebook® advertising)

To assist with recruitment a budget of $500(AU) was applied to the Facebook® post from the 'host' page and an audience specified within Facebook's® 'advertisement manager,' as per survey 1 (section 3.2.3.3). This 'sponsored' post resulted in 709 'link clicks' (from 29,460 Facebook® users reached) and the recruitment of 335 participants within the target audience into the survey (table 37).

3.3.4 Survey measures

The HBM and SCT were chosen as relevant theoretical frameworks to guide the development of survey items since constructs of the HBM attempt to understand behavioural motivations while the SCT support understanding of, and consequently change in, health related behaviours through cues to action. [346, 350] Furthermore, the HBM and SCT are frameworks commonly used by researchers across the literature, thus the results of this study are readily adaptable to future intervention design.

Parents were asked to identify if their child has a medical condition affecting their growth, development or metabolism, and children were excluded from participating in this study based on this response. Incomplete surveys were excluded from analysis in accordance with ethics approval. The survey was piloted in a convenience sample of parents with young children.

A total of 31 questions were included.

The survey collected:

- Responding parent's and reference child's sex,
- Parent-reported response to inclusion/exclusion criteria,
- Child age, to the nearest half year,
- Demographic data (income [categorical increments of $1500, from less than $25,000 to more than $150,000], family structure [single parent or other], state of residency [categorical], and region of residence [categorical response based on rural, remote and metropolitan areas (RRMA) classification]), [372]
- Parent's behavioural motivations,
- Parent's cues to action,
- Intervention champion,

See survey 2 in table 7.

3.3.4.1 Parent's behavioural motivations

To capture responding parent's behavioural motivations regarding participating in a child feeding intervention, parents were asked to categorically identify concerns regarding their child's weight (overweight and underweight), and eating behaviours (overeating, undereating, fussy eating, high intake of discretionary food), as well as perceived barriers in addressing these concerns. Parents were asked to categorically identify strategies and skills they would be interested in learning to address their concerns, and the delivery mode they would prefer for such a learning experience (table 7).

3.3.4.2 Parent's cues to action

Parent's cues to action were captured in categorical questions reflecting the frequency with which parent's access Facebook®, participate in Facebook® groups, and the type of content they share and engage with on Facebook®. Parents were asked to indicate if they would join a Facebook® group as an intervention platform (binary coded, yes/no), if they would be concerned about their privacy in this group (binary coded, yes/no), the type of content they would access (categorical), how often they would expect new content posted (categorical), and how quickly they would expect administration of a Facebook® intervention to respond to participant comments or questions (categorical). All survey items were devised for this study (table 7).

3.3.4.3 Intervention champion

Parents were asked to report their receptiveness to participate as an intervention 'champion.' The idea of a 'champion' draws from public health concepts and is a unique and novel construct intended to enhance social media-based interventions by using select participants to support researchers by being highly engaged in the research project and facilitating participant engagement, discussion, questions and posts within an online intervention. This survey item was recorded categorically (yes/ no/ unsure) (table 7).

Table 7: Survey questions as they align with constructs of the HBM[1] and SCT[2]	
Perceived risk, severity, susceptibility[1]	Are you concerned about your child? (categorical) • being overweight • being underweight • being a 'fussy' eater e.g. eating a limited number of foods, refusing to participate in meals, • under eating e.g. not eating enough food • overeating e.g. eating too much food How serious are the consequences of these concerns? (Likert) How important is it to you that you get information and support to address these concerns? (Likert) How motivated are you to make changes to improve these areas of concern? (Likert)
Perceived barriers[1], reciprocal determinism[2]	What barriers might prevent you from making changes to improve these concerns? (categorical) • Time • Money • Family support • Confidence • Cooking skills • Shopping skills • Knowledge about food and nutrition • Knowledge about child growth and development • Just too hard (self-efficacy) • Don't know what to do or where to get help • Other • No barriers
Perceived benefit (how, when, where to take action)[1], expectations[2], relevant knowledge/ behavioural	Would you be interested in learning strategies and skills to: (tick all that apply) • Support your child eat the right amount of food (not too much, not too little) • Support your child eat the right type of food (increase preference for fruits and vegetables, rather than discretionary foods such as chips, lollies, cakes, fried foods) • Reduce your child's fussy eating (increase the number or variety of foods eaten, increase participation and cooperation in meals) • Help you create tasty, healthy family meals • Help you create affordable family meals • Help you prepare quick meals

capabilities[2]	In thinking about the previous question: What would be the best way for you to develop the skills and strategies selected? (select 1) • Website information and materials • Email information and materials • A Facebook® group setting • A combination of online platforms only (e.g. website, email, and/or Facebook® group) • A face-to-face education group A one-on-one setting • A combination of a face-to-face group and online platforms (e.g. website, email, and/or face-to-face group)
Cues to action	How often do you login to Facebook®? (continuous 0 – 5) Are you an active member of any Facebook® groups? (categorical) What type of content do you engage with (read, view, comment, react to [e.g. like]) on Facebook® (either in groups, on pages or in your personal feed)? (categorical) What type of content do you share on Facebook® (either in groups, on pages or in your personal feed)? (categorical)
Increasing self-efficacy & behavioural capabilities	*In the following questions, the phrase *'support feeding your child'* - refers to skills, strategies and knowledge provided by a child feeding specialist (University qualified Nutritionist/Researcher) to support your child eat appropriate amounts and types of food, and the supporting skills, strategies and knowledge parents need to select and prepare healthful foods, create positive meal times and eating opportunities.
	Would you join a Facebook® group run by a child feeding specialist to get support feeding your child? (binary) Would you be concerned about your privacy if you joined a Facebook® group to get support feeding your child? (binary) If you were to join a Facebook® group to get support with child feeding*, would you access: (categorical) If you were to join a Facebook® group to get support with child feeding* what type of information would you share? (categorical) How often would you expect admin of a Facebook® group providing support for child feeding* to post new content (text posts, photos, videos, discussion topics) (continuous 0 – 5) If you joined a Facebook® group get support with child feeding*, how often would you access this group? (continuous 0 – 5)

	How quickly would you expect admin of a Facebook® group providing support for child feeding* to answer questions or respond to posts? (1-5)
Social desirability bias	Do you think you would be more or less honest/frank about your personal circumstance and experiences in a Facebook® group compared to a face-to-face in a group? (categorical 1 – 3)
Champion	If you were provided with appropriate guidance, would you consider being involved with a research project as a 'Champion'? (categorical)

3.4 Statistical analysis

The statistical method used to analyse the data as relevant to each research aim (1 – 5, section 3.1) are discussed in the following section, preceding presentation of the relevant results. All analyses were carried out using SPSS v24/v25 (SPSS Inc., Chicago, IL, USA).

Descriptive and frequency data were created using SPSS v25 (SPSS Inc., Chicago, IL, USA). Confidence intervals (CI) were calculated to provide estimates of sample parameters using standard t-distribution formula based on sample means. All hypothesis assumed a 0.05 significance level and a two-sided alternative hypothesis.

4. Results

Utilising the cross-sectional data derived from survey 1, results addressing research aims 1 – 4 have been presented in section 4.1. These results are a continuation of the first two components of the 4-component process in planning health interventions and further comprise determinants analysis within the capacity building stages (figure 8). Following this, results derived from survey 2, addressing research aim 5, have been presented in section 4.2. These results are a continuation of the second two stages of the 4-component process in planning health interventions and further comprise action components within the capacity building stages (figure 8).

Figure 8: Thesis mapping schematic model – Chapter 4

4-component process [45, 46]	**Capacity building stages** [50]		**Thesis chapter 4 key points**
1. Identification of modifiable factors which could be target behaviours ***2. Identification of potential mediators*** ***3. Selection and justification of theoretical model***	**Assessment**	Define needs and analyses problem	**Chapter 1: Introduction** • Childhood obesity major public health issue • Family food environments are the central context in which early childhood obesity emerges **Chapter 2: Literature review** • Children's eating behaviours associated with child weight status • Family food environments provide a key context in which childhood obesity develops through interactions with eating behaviours • Family food environments offer opportunity for intervention directed towards eating behaviours and obesity development • The social cognitive theory (SCT) and health belief model (HBM) provide a suitable framework for intervention planning • Technology offers new opportunity for intervention delivery
	Analysis **Action**	Determinant analysis	**Chapter 3: Methods** 3.2 Survey 1: Eating behaviours & family food environment 3.3 Survey 2: Intervention opportunities & acceptability **Chapter 4: Results** • **Survey 1** 4.13 <u>Paper 2:</u> Eating behaviour traits associated with psycho-social variables and implications for obesity outcomes in early childhood 4.14 Family food environment in Australia and children's eating behaviours 4.15 <u>Paper 3:</u> An examination of children's eating behaviours as mediators of parents' feeding strategies on early childhood obesity 4.16 <u>Paper 4:</u> Family food environment factors associated with obesity outcomes in early childhood

4 Design intervention	**Assessment**	Explore strategy options	• **Survey 2** 4.2.3 Paper 5: Prospects for early childhood feeding interventions: An exploration of parent's concerns and acceptability towards social media intervention opportunities.
		Implement the strategy portfolio & evaluation (Planning only)	**Chapter 5: Future direction & conclusion** 5.1 Overall discussion 5.2 Recommendations for intervention design

4.1 Survey 1

4.1.1 Recruitment outcomes - Facebook® advertising

Based on reports generated by Facebook®, from the $460 (AU) budget applied, 3162 Facebook® users in the target audience 'engaged' with the sponsored post at an average cost of $0.17 per engagement. Of this engagement, 142 people 'reacted' to the post (e.g. *Liked* the post), 100 people left comments, 121 people 'shared' the post and 2321 'clicked' through to the website. Based on these rates, there was roughly a 50% conversion rate from 'click through' to survey participation with a preliminary sample of 1296 recruited into the study.

Of the Facebook® users engaged with the post, 97% were women (1% male, 2% unknown), 6% were 18 – 24 years, 52% were 25 – 34 years, 40% were 35 – 44 years, and 1% were 45 – 54 years. All states of Australia were also reached (2% ACT, 25% NSW, 1% NT, 25% QLD, 10% SA, 2% TAS, 20% VIC, 12% WA). Fifty-four percent (54%) of users engaged with the post on an iPhone® and 36% on an Android Smart phone, which may be important information for future research in terms of ensuring websites and survey platforms are compatible with these devices. Peak times of engagement were also reported, with rates increasing throughout the evening until between 9pm and 10pm (time zone not indicated). Again, this information may be of relevance for future recruitment purposes.

4.1.2 Sample characteristics

On initial screening of the data (n=1296) 98 cases were removed due to incomplete data, as per ethics requirements, and 12 cases were removed as it was indicated that the child met the exclusion criteria based on parent's response to the item 'Does your child have a disability or medical condition which affects their growth, development or metabolism?'

4.1.2.1 Child BMIz

Based on the method of detecting biologically implausible values described in section 3.2.5.1, 18.5% (n=208) of the initial sample were excluded.

Figure 9: Screening for biologically implausible values

Initial data = 1296
Removal of incomplete data (n=110; leaving n= 1186 with complete data)
Remove height Z scores less than 3 (n=35)
Remove height Z scores greater than 3 (n=144)
Dataset = 1007
Remove weight Z scores less than 3 (n=4)
Remove weight Z scores greater than 3 (n=17)
Dataset = 986
Regress weight Z score on height Z score remove residuals greater of less than 2.5 (n=8)
Screened dataset = 978

This rate of biologically implausible values is similar to that reported in a study of children 2 – 5 years (20.5% - 16.5% implausible), based on parent reported data, although other studies have reported much lower rates (7.9% - 9.7%). [388, 389] Limited data availability makes comparison difficult as does no standard method of reporting biologically implausible values. Similar to what has been reported in other studies, misreporting of anthropometric data was higher in boys, although, contrary to other studies, implausible data were higher in younger children. [390, 391]

From the retained sample, child BMI categories were additionally determined according to Cole, 2000 and 2007. [47, 48] Findings from the previously reported meta-analysis further indicated that the use of self-reported data are more likely to result in under-identification of positive cases (i.e., overweight and obese participants), but less likely to include negative cases (i.e., non-overweight and non-obese participants). [392] This should be kept in mind with regard to the BMI categories derived in this study.

Once cases of biologically implausible values were removed, rates of overweight and obese children in this study (11.1% and 6.5%, respectively) were similar to those reported in national data of children age 4 - 5 years of 15.2% overweight and 5.5% obese. [10] Rates of underweight children in this sample (n=22.4%), however, are likely over-represented compared with national data (n=7.55%), which similarly reduced rates of normal weight children in this sample (n=59.9%) compared with nations data (67.75%; table 6, section 4.1). [10] Child BMIz were checked for normality and was deemed skewed so transformed accordingly.

4.1.2.2 Parent BMI

Parent's BMI were initially visually screened for very high or very low values. Based on this, 2 cases were removed from further analysis due to very low values (BMI 9.26kg/m^2 and 10.33kg/m^2, created due to extremely high height with very low weight). No cases were removed based on very high BMI values. Based on this method, parent BMI data were available for 1184 participants. This sample was used for analysis that was independent of child BMIz. It should be noted that, because of the exclusion of parents with implausible BMI an additional child was lost from analysis that included both parent and child BMI data. This gave a final sample of 977 cases with both parent and child BMI data. The Cronbach α presented in section 3.2.5 are based on the sample including both parent and child (n = 977) as this was the sample predominantly used for further analysis in this thesis.

Despite parental BMI being self-reported, rates of overweight (26.0%) and obese (32%) were similar to those reported in national samples of Australian adults (27.6% overweight, 33.7% obese, women 35 - 44 years, table 8). [10, 19, 20] On checking for normality, parent's BMI were also deemed shewed so were transformed accordingly.

4.1.2.3 Demographic characteristics

All states in Australia and geographic regions have been represented in this sample. Rates of single parents in this study were 12%. Distribution of participants in the high and middle-income groups were similar (45% and 42%, respectively), however, low income families appear underrepresented (13%). While this study refers to 'parents,' mothers were prominent respondents in this study (94%). This under-representation of fathers' limits ability to conduct analysis of this sub-sample. See table 8 for further details of the sample characteristics**.**

Table 8: Demographic data		
	Full Sample % (n = 1184)	Sample excluding biologically implausible values % (n = 977)
Gender		
Boy	51% (602)	49% (483)
Age		
2 years	12% (143)	11% (108)
2.5 years	18% (214))	17% (161)
3 years	16% (191)	16% (153)
3.5 years	17% (198)	17% (164)
4 years	17% (197)	18% (173)
4.5 years	12% (138)	13% (128)
5 years	9% (103)	9% (90)
Child BMI category[a]		
Underweight	27% (324)	22% (219)
Normal	54% (634)	60% (586)
Overweight	10% (120)	11% (109)
Obese	9% (106)	7% (63)
Child BMI z-score[b]	-0.502 (SD 2.62)	-0.181 (SD 1.79)
Child weight z-score	0.45 (1.17)	0.36 (1.07)
Child height z-score	0.90 (2.06)	0.57 (1.28)
Parent gender		
Male	6% (66)	5% (52)
Single parents (binary coded)	11% (133)	12% (114)
Parent BMI category[c]		
Underweight (<18.50kg/m^2)	1% (16)	1% (13)
Normal weight (18.50 – 24.99kg/m^2)	39% (464)	41% (398)
Overweight (≥25.00kg/m2)	27% (318)	26% (254)
Obese ≥30.00kg/m^2)	33% (386)	32% (312)
Breastfeeding history		
Less than 6 months	37% (441)	37% (357)
6 months or more	63% (743)	63% (620)
Income		
Low: less than AU$40,000	13% (151)	13% (129)
Middle: AU$40,000 – 100,000	42% (500)	42% (407)
High: more than AU$100,000	45% (533)	45% (441)
Australian state		
Victoria	18% (210)	18% (173)
New South Wales	25% (301)	25% (246)
Queensland	30% (354)	30% (292)
Australian Capital Territory	3% (32)	3% (28)
Western Australia	12% (146)	13% (122)
Tasmania	3% (34)	3% (29)
Northern Territory	1% (7)	1% (5)
South Australia	8% (100)	8% (82)
Region type		

Capital city	25% (298)	26% (255)
Metro (population over 100,000)	31% (369)	31% (301)
Large rural (population 25,000 – 99,999)	21% (244)	19% (188)
Small rural (population 10,000 – 24,999)	13% (154)	13% (128)
Large remote (population 5,000 – 9,999)	4% (45)	4% (41)
Small remote (population less than 5,000)	6% (74)	7% (64)
Sleep		
Minimum	4 hours	4 hours
Maximum	14 hours	14 hours
Mean	10.67 (SD 1.11)	10.67 hours (SD 1.11)
Mean number of children in the home	2.06 (SD 0.88)	2.07 (SD 0.88)

N (%) reported for dichotomous variables

Mean (SD) reported for continuous

[a]Cut offs per Cole, TJ. (2000 and 2007)

[b]2000 CDC growth charts

[c]Cut offs per WHO classifications for adults (2000)

Text and tables within section 4.1.3 are a reproduction of the manuscript published in the journal Appetite except for edits which have been made to the following sections to improve the statistical rigour of the paper.

Edits made to section *Statistical Method, Relation [Correlation] between psycho-social variables, child BMI z-score and income* and *Table 11 – 12*.

The citation is as follows:

Boswell, N., Byrne, R., & Davies, P. S. W. (2018). Eating behaviour traits associated with demographic variables and implications for obesity outcomes in early childhood. Appetite, 120, 482-490. Doi: https://doi.org/10.1016/j.appet.2017.10.012

Contributor	Statement of contribution
Nikki Boswell	Conception and design of the study (60%) Analysis and interpretation of the data (60%) Drafting and critical review of manuscript (60%)
Rebecca Byrne	Conception and design of the project (20%) Analysis and interpretation of the data (20%) Drafting and critical review of manuscript (20%)
Peter Davies	Conception and design of the project (20%) Analysis and interpretation of the data (20%) Drafting and critical review of manuscript (20%)

4.1.3 Paper 2: Eating behaviour traits associated with demographic variables and implications for obesity outcomes in early childhood

4.1.3.1 Background

Despite the attention that childhood overweight and obesity has been given over the past few decades, it remains an issue of major public health concern, with rates reaching around 20% among Australian children aged 2 – 3 years (2007) and around 27% among children aged 5 -17 years (2014 – 2015). [10, 11, 393] The emergence of overweight and obesity at such early stages of life is particularly concerning given that being overweight and obese during childhood significantly increase the risk of being overweight and obese as an adult, as is associated with an increased risk non-communicable disease in both the long and short term. [394]

According to the behavioural susceptibility theory, obesity emerges when genetic susceptibility interacts with environmental circumstances and 'obesogenic' behaviours ensue. [2] In accordance with this, eating behaviours provide a potential intermediary pathway from which obesity development can be better understood and prevention initiatives targeted. In particular, the early childhood period offers a unique and critical window for such intervention, as it is during this period that eating behaviours emerge and are reinforced to provide a foundation for obesogenic behaviour throughout the lifespan. [65] This intermediary role of eating behaviours in childhood obesity can be seen across the literature which shows food approach eating behaviours such as food responsiveness and enjoyment of food to be positively associated with overweight and obesity, while food avoidance eating behaviours such as satiety responsiveness, slowness in eating and food fussiness, are associated with reduced overweight and obesity outcomes. [5, 7, 57]

In attempting to understand this role of eating behaviours in early childhood obesity, attention has largely been given to proximal, micro-environmental factors, such as parent's feeding strategies, which are considered to have a pivotal influence on child behaviour. [294, 395] Far less attention, however, has been given to exploring psycho-social variables which may underpin eating behaviours, such as parent's stress and depression, low income status, single-parent status, and/or short sleep duration, which have been seen to internally alter appetite regulatory systems. [13, 91, 100-102, 104-107, 396-398] For the purposes of this paper, a distinction will be made between micro-environment determinants of eating behaviours and psycho-social determinants of eating behaviours, by using the term *eating behaviour traits* to refer to the latter.

Current understanding of the eating behaviour traits that underpin childhood overweight and obesity postulates that alteration in the homeostatic regulation of food intake, as coordinated by neuroendocrine feedback loops, involving nutrient and hormonal signals, results in a down regulation of food avoidance eating behaviour traits and/or an up regulation of food approach eating behaviour traits. [5, 73, 74] These alterations may be a consequence of internal susceptibility to inappropriate responses to homeostatic regulatory systems or a vulnerability of these systems to be overridden by external influences. Additionally, vulnerability to hedonic eating (eating for pleasure in the absence of energy deficits), neurologically, can contributes to overweight and obesity through excess energy intake. [95]

These systems, particularly during early childhood, are vulnerable to epigenetic changes and/or changes in neurological structure in response to certain environmental circumstances. [3, 182, 396, 399, 400] That is, while eating behaviour traits are estimated to have approximately 50% heritability, it is possible that they are manipulated and shaped through shared environment which is similarly estimated to account for approximately 45% of variance in eating behaviour traits. [3] For instance, alterations in the appetite regulating hormones leptin, ghrelin and cortisol, under control of the hypothalamic-pituitary-adrenal [HPA] axis, have been noted as a result of chronic stress, reduced breastfeeding, reduced sleep duration, and general 'disadvantaged' life circumstances. [13, 91, 100-102, 104-107, 396-398] Furthermore, it is understood that children from low socio-economic backgrounds often experience greater neurological impulsivity and reward seeking behaviour, as has been associated with increased food approach behaviours and obesity development. [74, 401, 402] This underpinning of chronic stress and adversity on appetite and eating behaviours traits highlights a potential pathway from which higher rates of obesity in disadvantaged sub-population groups could be explained, however are yet to be extensively explored. [10, 19, 146]

Given this, this study aims to determine psycho-social demographic variables associated with eating behaviours traits and the relationship these traits have with obesity development in Australian children during early childhood. It is hypothesized that low income status, single-parent status, short sleep duration, parent's depression, stress and anxiety, and breastfeeding duration, will be associated with obesogenic eating behaviour traits in children. Gaining understanding of such interaction of these psycho-social variables provides a new perspective in approaching childhood obesity and support alternative/novel preventative focus.

4.1.3.2 Materials and Method

Recruitment

Between July and November, 2016, Australian parents of children aged 2.0 – 5.0 years self-enrolled to complete an online, cross sectional survey. Participants were invited to enrol in the survey through advertising on the social media website Facebook®. The advertisement provided brief information about the survey and provided a link to a website which contained further details about the research project as well as the plain language statement, participant consent form, and access to the online survey, hosted by Checkbox®. Children were excluded from this study if parents reported the child had a medical condition likely to affect the child's growth, development or metabolism. In the instance that a parent had more than one child within the target age, parents were asked to refer to the child whose birthday occurred next.

Measures

Self-selected parents responded to questions regarding their child's age, gender, parent/respondent gender, single parent status, income, state and region of residency, sleep duration, breastfeeding history, parent depression, anxiety and stress, and children's eating behaviours. These variables were selected for inclusion in analysis as identified to be psycho-social variables associated with eating behaviours and/or obesity development across the literature.

Participants were prompted to use household measures (e.g. bathroom scales/ household tape measure) to report child weight and height which were subsequently used to calculate weight, height and BMI z-scores according to the 2000 CDC growth charts. [381] Use of CDC growth charts for children from 2 years of age is consistent with the recommendations of the National Health and Medical Research Council (NHMRC). [17] Child BMI categories were additionally determined according to Cole, 2000 and 2007. [47, 48]

Parents were also prompted to use household measures to report their weight and height which were used to calculated BMI scores and BMI categories in accordance with the World Health Organizations classifications (Underweight <18.50kg/m^2; Normal weight 18.50 - 24.99kg/m^2; Overweight ≥25.00kg/m^2; Obese ≥30.00kg/m^2). [49]

Data Screening and sample size

As child height and weight were by parental report it was deemed necessary to screen the data for biologically implausible values (BIVs). Although there is no standard approach to assessing BIVs, Flegal and Cole (2013) reported that using the CDC BMI reference data to calculate BMI z-scores that are then screened for BIVs will lead to errors if a modification of the BMI z-score is not undertaken. [382, 383] The process of calculating what is referred to as a "modified Z score" is complicated and not universally supported, thus the process used to screen for BIV's in this paper involved a twostep approach. Firstly, all weight or height z-scores greater or less than 3 were discarded. Secondly, after regressing weight z-score on height z-score any residuals greater or less than 2.5 were also discarded.

Parents BMI were also visually screened for very high or very low values, however no cases were excluded based on this visualization.

Children's eating behaviour traits

Child eating behaviour traits were measured using five of the eight sub-scales of the children's eating behaviour questionnaire (CEBQ) and showed acceptable internal reliability in the present study; enjoyment of food (4 items; Cronbach α 0.868); food responsiveness (5 items; Cronbach α 0.921); satiety responsiveness (5 items; Cronbach α 0.800); slowness in eating (4 items; Cronbach α 0.709); and food fussiness (6 items; Cronbach α 0.677). This shortened version of the CEBQ was chosen to minimize participant burden and as each sub-scale has previously shown good psychometric properties and good internal reliability with Cronbach's alpha values between 0.73 and 0.91 when validated in an early childhood population (1 – 5 years) in Australia. [179] The sub-scales selected were nominated so as to allow comparison across the literature. [5, 67] Items were scored on a 5-point scale, with higher scores indicating higher values of each trait. Mean scores for each sub-scale were calculated. [67]

Parental depression, anxiety and stress

Parental depression, anxiety and stress was measured using the DASS-21, depression, anxiety and stress scale. [373] The DASS-21 is a 21 item self-report questionnaire designed to measure the severity of a range of symptoms common to depression, anxiety and stress over the previous week. [403] This study similarly showed high internal reliability across all 3 scales (stress [7 items; Cronbach α 0.837]), anxiety [7 item; Cronbach α 0.742], depression [7 items; Cronbach α 0.886]).

Statistical method

All analyses were carried out using SPSS v24 (SPSS Inc., Chicago, IL, USA). The distribution of predictive variables were examined for multicollinearity and normality (skewness and kurtosis between 1 and -1). Parent mean depression scores, parent mean anxiety scores, and parent BMI were deemed skewed so transformation was performed on these variables accordingly. Upon transforming parents BMI, one outlier was identified and thus excluded from further analysis.

CEBQ sub-scales were normally distributed (skewness and kurtosis between 1 and -1) and had good internal consistency, with Cronbach's α over 0.677.

To examine whether BMI categorization showed linear associations with eating behaviour traits a one-way between-groups multivariate analysis of variance was performed with BMI category as the independent variable and the three CBEQ sub-scales significantly correlated with child BMI category (food responsiveness, enjoyment of food, satiety responsiveness, and food fussiness) as dependent variables. Pillai's Trace was examined for significance, homogeneity of variance assumption examined with Levene's F tests, a series of one-way ANOVA's on each of the CEBQ sub-scales was conducted as a follow-up tests to the MANOVA, and post-hoc contrasts (LSD) performed. [7]

Pearson's correlations were used to assess relationships between CEBQ scores and child BMI z-score, and between continuous psycho-social variables and child BMI z-score, as appropriate [5, 55]. Where significant, linear regression was conducted and coefficients, confidence intervals and mean scores inspected to check the direction and pattern of the association. [5] To examine the relationship between child BMI z-score and categorical psycho-social variables ANOVA and Chi-square tests were conducted as appropriate. Multiple regression analysis was applied to examine associations between select variables (child age, child gender, duration of sleep, parent BMI, breastfeeding less than 6 months (binary coded with breastfeeding longer than 6 months), low income status, single parent status, and parental DASS scores) and CEBQ scores. Stepwise regression was used to determine eating behaviour traits and demographic variables associated with child BMI z-score. All hypotheses will assume a 0.05 significance level and a two-sided alternative hypothesis.

4.1.3.3 Results

From the initial sample of 1186 participants that had completed the survey, once cases of BIV and outliers were removed, a final sample of 977 Australian children, aged between 2.0 and 5.0 years, were retained with plausible BMI data. Excluded cases did not differ significantly based on parent BMI category, parent gender, single parent status, income group, or state or region of residency in one-way ANOVA analysis, however were significantly younger (mean age 3.1 years, compared with 3.4 years, p=0.000) and were significantly more likely to be boys (58.0% in excluded case compared with 49.4% in retained sample, p=0.026).

Participants represented all states and territories of Australia, from a variety of geographic regions. The majority of parent responders were mothers (94.7%) and 11.7% were single parents. Further demographic variables of participants can be seen in table 9.

Table 9: Demographic data (n = 977)

Gender - Boy	483 (49.4)
Age	
2 years	108 (11)
2.5 years	161 (16.5)
3 years	153 (15.6)
3.5 years	164 (16.8)
4 years	173 (17.7)
4.5 years	128 (13.1)
5 years	90 (9.2)
Child BMI category[a]	
Underweight	219 (22.4)
Normal	586 (59.9)
Overweight	109 (11.1)
Obese	63 (6.5)
Child BMI z-score[b]	-0.181 (SD 1.79)
Parent gender	
Men	52 (5.3)

Single parents	
Single	114 (11.7)
Parent BMI category[c]	
Underweight (<18.50kg/m^2)	13 (1.3)
Normal weight (18.50 - 24.99kg/m^2)	398 (40.7)
Overweight (≥25.00kg/m2)	254 (26.0)
Obese ≥30.00kg/m^2)	312 (32)
Breastfeeding history	
Less than 6 months	358 (36.6)
6 months or more	619 (63.4)
Income	
Low: less than AU$40,000	129 (13.2)
Middle: AU$40,000 - 100,000	407 (41.6)
High: more than AU$100,000	441 (45.2)
Australian state	
VIC	173 (17.7)
NSW	246 (25.2)
QLD	292 (30.0)
ACT	28 (2.9)
WA	122 (12.5)
TAS	29 (3.0)
NT	5 (0.5)
SA	82 (8.4)
Region type	
Capital city	255 (26.1)
Metro (population over 100,000)	301 (30.8)
Large rural (population 25,000 – 99,999)	188 (19.3)
Small rural (population 10,000 – 24,999)	128 (13.1)
Large remote (population 5,000 – 9,999)	41 (4.2)
Small remote (population less than 5,000)	64 (6.5)
Sleep	
Minimum	4 hours
Maximum	14 hours
Mean	10.67 hours (SD 1.11)

N (%) reported for dichotomous variables
Mean (SD) reported for continuous
[a]Cut offs per Cole, TJ. (2000 and 2007)
[b]2000 CDC growth charts
[c]Cut offs per WHO classifications for adults (2000)

Correlation between eating behaviour traits and child BMI z-score

Significant correlations were detected between all CEBQ sub-scales and child BMI z-score, except slowness in eating. Significant correlations were also detected between all CEBQ sub-scales, such that, food approach traits (enjoyment of food and food responsiveness) were negatively correlated with food avoidance traits (satiety responsiveness, food fussiness and slowness in eating), while food approach traits were positively correlated with each other (enjoyment of food and food responsiveness), as were food avoidance traits (satiety responsiveness, food fussiness and slowness in eating; table 10).

Table 10: Correlations between CEBQ Sub-scales and child BMI z-score

	Food Responsiveness	Enjoyment of Food	Satiety Responsiveness	Slowness in Eating	Child BMI Z-score
Food Fussiness	-.072*	-.651**	.435**	.292**	-.073*
	.024	.000	.000	.000	.022
Food Responsiveness		.333**	-.401**	-.201**	.096**
		.000	.000	.000	.003
Enjoyment of Food			-.541**	-.361**	.068*
			.000	.000	.034
Satiety Responsiveness				.403**	-.105**
				.000	.001
Slowness in Eating					-.061
					.058

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

<u>Relation between psycho-social variables, child BMI z-score and income</u>

Significant correlations were seen between child BMI z-score and parent BMI (p=0.029), but no other variables (table 11).

Table 11: Correlations between psycho-social variables and child BMI z-score

	Sleep Duration	Parent Stress	Parent Depression	Parent Anxiety	Parent BMI
Child BMIz	.011	-.029	-.032	-.004	.070*
	.733	.372	.313	.891	.029
Sleep duration		-.152**	-.165**	-.169**	-.136**
		.000	.000	.000	.000
Parent stress			.713**	.605**	.101**
			.000	.000	.002
Parent depression				.580**	.177**
				.000	.000
Parent anxiety					.141**
					.000

Parent BMI					1
*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).					

In ANOVA model's no significant differences were seen in child BMI z-score between categories of single parent status (F=0.318, p=0.573), breastfeeding duration (F=1.22, p=0.269) or income category (F=0.630, p=0.533; table 12). Significant differences were detected, however, between income category and child sleep duration, parent's BMI, parent's stress, depression and anxiety, breastfeeding duration, and single parent status (table 12).

Table 12: Psycho-social variable differences by income group (ANOVA and Chi-square)

	Low Income (Mean [SD]) (n=129)	**Middle income (Mean [SD]) (n=407)**	**High Income (Mean [SD]) (n=441)**	**Significance (weighted p value)**	
Child BMIz	-.0284 (2.00)	-.1845 (1.72)	-.2295 (1.78)	ns	
Sleep	10.38 (1.37)	10.70 (1.20)	10.74 (.91)	.004	
Parent stress	1.01 (.54)	(.77) (.49)	.78 (.46)	.000	
Parent depression	.62 (.52)	.42 (.49)	.34 (.40)	.000	
Parent anxiety	.44 (.43)	.29 (.35)	.25 (.30)	.000	
Parent BMI	29.76 (7.706)	28.59 (7.26)	26.77 (6.04)	.000	
	n (%)	**n (%)**	**n (%)**	**Chi-square value (df)**	**Significance (p value)**
Breastfeeding less than 6 months	63 (48.8%)	161 (39.6%)	133 (30.1%)	17.75 (2)	.000
Single parent	76 (58.9%)	34 (8.4%)	4 (0.9%)	333.27 (2)	.000
*ns; not significant					

Eating behaviours traits across BMI categories

A statistically significant difference existed between BMI category for the dependent variables (food responsiveness, enjoyment of food, satiety responsiveness, and food fussiness) in the MANOVA, with Pillais' Trace= 0.022, F(12, 2907) = 1.79, p= 0.044. The multivariate effect size was estimated at 0.007, which implies that 0.7% of the variance in the dependent variable was accounted for by BMI category. Based on a series of Levene's F tests, the homogeneity of variance assumption was considered satisfied, with all sub-scales failing to reach significance. A series of one-way ANOVA's on each of the CEBQ sub-scales was finally conducted as a follow-up test to the MANOVA. Only ANOVA's for enjoyment of food, food responsiveness and satiety responsiveness were statistically significant (p=0.012, p=0.005, p=0.008, respectively), with effect sizes (partial n^2) ranging from 0.011 to 0.013.

Finally, a series of post-hoc analyses (Fisher's LSD) were performed to examine individual mean difference comparisons across BMI categories and CEBQ subscales. The results revealed statistically significant differences in enjoyment of food between underweight and overweight (p=0.002) and normal weight and overweight (p=0.026). Food fussiness differed significantly between underweight and overweight (p=0.027). Food responsiveness differed significantly between underweight and normal weight (p=0.044), underweight and overweight (p=0.002), and underweight and obese (p=0.009). Satiety responsiveness differed significantly between underweight and normal weight (p=0.035) overweight (p=0.004), and between underweight and obese (p=0.009; table 13).

Table 13: CEBQ sub-scale differences by child BMI status (MANOVA)

CEBQ SUB-SCALES	Underweight (n=219)	Normal Weight (n=586)	Overweight (n=109)	Obese (n=63)	Linear Trend (weighted p value)
Enjoyment of food	3.8 (.74)	3.9 (.71)	4.0 (.67)	4.0 (.73)	0.012
Food fussiness	2.9 (.97)	2.8 (.91)	2.7 (.89)	2.7 (1.01)	0.088
Food responsiveness	2.1 (.72)	2.5 (.75)	2.7 (.80)	2.7 (.81)	0.005
Satiety responsiveness	3.2 (.61)	3.1 (.58)	3.0 (.61)	3.0 (.56)	0.008
Slowness in eating	3.2 (.72)	3.2 (.68)	3.0 (.66)	3.1 (.69)	ns
*ns; not significant					

Associations between eating behaviour traits and BMI z-score

Using linear regression models each CEBQ sub-scales, except slowness in eating, significantly predicated child BMI z-score, such that for each unit increase in Food responsiveness and enjoyment of food child BMI z-score increased by 0.23 (R^2 =0.009, F=9.001, p=0.003) and 0.17 (R^2 =0.005, F=4.479, p=0.035) respectively, and for each unit increase in food fussiness and satiety responsiveness child BMI z-score decreased by 0.14 (R^2 =0.005, F=5.114, p=0.024), and 0.32 (R^2=0.011, F=10.956, p=0.001), respectively (table 14).

Table 14: CEBQ sub-scale and BMI z-score linear regression							
Coefficients[a]							
	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
Food responsiveness	.226	.075	.096	3.000	.003	.078	.373
Enjoyment of food	.169	.080	.068	2.116	.035	.012	.326
Satiety responsiveness	-.318	.096	-.105	-3.310	.001	-.507	-.130
Food fussiness	-.139	.060	-.072	-2.261	.024	-.259	-.018
Slowness in eating	-.155	.083	-.060	-1.872	.061	-.318	.007
a. Dependent variable: Child BMI z-score							

Predicting BMI z-score

In multiple regression, predictors of child BMI z-score, explaining 5.7% of the variance in the model, included (F=11.674): being a boy (B=0.561, p=0.000), food responsiveness (B= 0.188, p= 0.020), child age (B= -0.204, p= 0.001), satiety responsiveness (B= -0.260, p=0.013) and parent BMI (B=1.413, p=0.012; table 15).

Table 15: Variables predictive of child BMI z-score in multiple regression							
Coefficients[a]							
	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
Model	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
(Constant)	-1.451	.934		-1.553	.121	-3.283	.382
Boy	.567	.112	.159	5.073	.000	.348	.787
Food responsiveness	.188	.081	.079	2.327	.020	.029	.346
Age	-.204	.062	-.104	-3.302	.001	-.325	-.083
Parent BMI	1.413	.565	.079	2.504	.012	.306	2.521
Satiety responsiveness	-.260	.104	-.086	-2.500	.013	-.464	-.056
a. Dependent variable: Child BMI z-score							

Predicting eating behaviour traits

In multiple regression models, enjoyment of food was predicted by sleep (B= 0.105, p= 0.000), single parent status (B=0.234, p=0.001), breastfeeding less than 6 months (B=-0.136, p=0.004), and parental depression (B=-1.343, p=0.009). Food fussiness was predicted by sleep duration (B= -0.133, p=0.000), parental depression (B= 2.711, p=0.000), single parent status (B= -0.323, p=0.000), child age (B= 0.079, p=0.014) and breastfeeding less than 6 months (B = 0.139, p=0.002). Food responsiveness was predicted by parental stress (B= 0.225, p=0.000), child age (B=0.079, p=0.003) and parent BMI (B=-0.494, p=0.041). Satiety responsiveness was predicted by parent BMI (B= 0.649, p=0.001), sleep duration (B=-0.060, p= 0.000) and child age (B= -0.059, p= 0.004). slowness in eating was predicted by parental stress (B=0.158, p=0.000; table 16).

Table 16: Variables predictive of eating behaviour traits in multiple regression										
	Enjoyment of Food		**Food Fussiness**		**Food Responsiveness**		**Satiety Responsiveness**		**Slowness in Eating**	
Covariates	B (SE)	B (P Value)	B (SE)	B (P Value)	B (SE)	B (P Value)	B (SE)	B (P Value)	B (SE)	B (P Value)
Sleep (hours)	.105 (.020)	.163 (.000)	-.133 (.027)	-.158 (.000)			-.060 (.017)	-.112 (.000)		
Single parent	.234 (.071)	.105 (.001)	-.323 (.092)	-.111 (.000)						
Breastfeeding less than 6 months	-.136 (.047)	-.092 (.004)	.139 (.061)	.072 (.022)						
Parent depression	-1.343 (.515)	-.084 (.009)	2.711 (.668)	.129 (.000)						
Child age			.079 (.032)	.077 (.014)	.079 (.026)	.095 (.003)	-.059 (.020)	-.092 (.004)		
Parent BMI					-.494 (.241)	.065 (.041)	.649 (.189)	.109 (.001)		
Parental stress					.225 (.049)	.146 (.000)			.158 (.045)	.113 (.000)

4.1.3.4 Discussion

This paper contributes to a growing body of evidence focusing on the role of eating behaviour traits as intermediaries in childhood obesity development. In this study food approach eating behaviour traits (enjoyment of food and food responsiveness) were associated with increased child BMI z-score while food avoidance eating behaviour traits (satiety responsiveness and food fussiness) were associated with decreased child BMI z-score, similar with what has been seen in other population. [5, 7] However, in linear trend analysis these relationships were not consistent across each BMI category. Further to this, after adjusting for child age, child gender, sleep duration, parents BMI, breastfeeding less than 6 months, low income status, single parent status, and parents DASS scores in regression analysis, only satiety responsiveness and food responsiveness were retained as eating behaviour traits significantly predictive of child BMI z-score. These finding suggest that obesity prevention initiatives should focus on food responsiveness as an obesity promoting trait and satiety responsiveness as an obesity reducing trait, and potentially the psycho-social demographic variables seen to predict them (as will be discussed below).

The association between food responsiveness and satiety responsiveness in childhood obesity in this study is consistent with the theory that overweight and obese children experience alterations in cues, internally and/or externally, which regulate eating commencement and cessation thus resulting in energy imbalance, as supported by the literature. [2, 5, 73, 74, 159] This key role of food responsiveness and satiety responsiveness in obesity development is further consistent with the high hereditability of these traits (59% and 72%, respectively), which is likely to reduce the vulnerability of these traits to environmental influence. [113] Similarly, slowness in eating has been reported to be 84% hereditable, thus potentially explaining why few psycho-social variables were associated with this trait in this study (table 16). [113]

In this regard, given the high hereditability of food responsiveness and satiety responsiveness, parents BMI showed associations with these traits in direction opposite to what was expected, which contradicts both the shared gene and shared environment theory. [2] A possible explanation for this unexpected finding could include parents use of feeding strategies which ‘override’ or interact with the child’s inherited eating behavior traits in an attempt to mitigate obesity development. [246, 252] Twin studies by Harris, et al (2016), and Tripicchio, et al (2014) have demonstrated that tendency of parents to modify their feeding practices in response to perceptions of an individual child's eating behaviour traits. [201, 202] Payne, et al (2011), additionally concluded that parents were more likely to use differential restrictive feeding practices when they had differential concern for the weight status of their children. [200] Contrary to parent's intentions, however, these types of feeding strategies are counterproductive in 'improving' eating behaviours and can be seen to further result in increases in child weight status. [246, 252] This is again consistent with the findings of Tripicchio, et al (2014), which showed that after controlling for shared environment and genetics, restrictive feeding practices were associated with child weight status. [202]

Given this bi-directional relationship between children's eating behaviours and obesity development, as explicitly explored by Jansen and colleagues (2012), and supported by the findings of this study, parents need to be supported in understanding the intermediary role of eating behaviour in obesity development and in adopting feeding strategies which are effective in reducing obesity risk. [38] Alternatively, given that the CEBQ is a parent reported measure, parent's perceptions and expectations on child eating could additionally explain the unexpected direction of the relationships noted. In order to clarify these finding, further objective studies are needed which specifically examine eating behaviour traits as intermediaries in the relationship between parent feeding strategies and child BMI outcomes, within the further context of multiple environmental variables which are likely to interact. Additionally, future work should include measures of both adult eating behaviour and child's eating behaviour in order to develop a clearer understanding of this relationship. Another unexpected finding was that low income status was not directly seen to relate to any eating behaviours traits as hypothesized. Despite this, parental stress, depression, single parent status, reduced breastfeeding duration and reduced sleep duration, as related to low income status, were associated with the eating behaviour traits. Given this, it is likely that the underpinning theory that these psycho-social variables influence eating behaviours traits remains valid, although the relationship with obesity development in unclear.

For instance, parents stress, as an 'adverse life circumstance' likely to drive changes in the HPA-axis that regulates appetite hormones, were positively associated with food responsiveness thus theoretically expected to have an obesity promoting effect, as consistent with the relationships between this eating behaviour trait and child BMI z-score reported in this study. Given this, intervention that gives attention to managing parents stress may assist reduce food responsiveness and in turn manage BMI trajectory. Contrary to what was expected, however, parent’s depression and child sleep duration related to eating behaviour traits in ways which would be expected to be obesity protective. That is, increases in parent depression was seen to be associated with reduced child enjoyment of food and increased food fussiness, while increases in sleep duration was seen to be associated with reduced food fussiness and satiety responsiveness, and increased enjoyment of food. This inconsistency, however, appears to align with the findings of Fildes, et al., (2015), who showed food fussiness and satiety responsiveness to be associated with lower preference for fruits and vegetables, while enjoyment of food is positively associated with liking for fruits and vegetables. [67]

Alternatively, the role of parents feeding practices may explain the relationship between parent’s depression and children’s eating behaviour traits. That is, parents depression has been associated with permissive parent feeding practices and in turn obesity, however the potential of eating behaviours as intermediaries in this relationship was not considered. [240] In regards to sleep duration, the potential of altered food preferences to explain the unexpected directions of predictive variables is somewhat consistent with hedonic associations between sleep duration and eating behaviour, through effect on the brains reward centre. [22, 95, 404-406] McDonald and colleagues (2015) similar reported that shorter sleep duration affects children’s food intake via hedonic, rather than homeostatic, processes by showing that in children, 5 years of age, food responsiveness was positively associated with shorter sleep duration. [107] McDonald and colleagues (2015), however, failed to show association between sleep duration and satiety responsiveness (unlike the present study), as deemed to reflect a homeostatic regulatory behaviour, and did not measure any other CEBQ sub-scales thus limiting greater comparability. [107]

Similarly, since breastfeeding less than 6 months was associated with increased food fussiness in the present study, it seems prudent to promote longer breastfeeding duration, along with increased sleep duration and management of parent depression, to reduce fussy eating and increase enjoyment of food, despite this contradicting the theorized roles of food avoidance and food approach eating behaviour in obesity. Additionally, breastfeeding duration may offer some protective benefit against homeostatic drivers of obesity through the HPA-axis, with more weeks breastfeeding seen to predicted quicker cortisol recovery in infants. [97, 104]

Although no association between breastfeeding and satiety responsiveness were seen in this study, the ‘fine-tuning’ of the HPA-axis during the early life period as supported by breastfeeding, offers a pathway to explain the greater satiety responsiveness (but not food responsiveness) noted with increased breastfeeding duration (persisting after controlling for maternal controlling feeding practices) in a cross-sectional study of 298 children. [407] It is again difficult to make comparisons between the results of this cross-sectional study with the present study, as not all CEBQ sub-scales were measured. [407]

These finds have implications, firstly, in supporting parents to manage stress and depression, to assist them develop good sleep habits with their child, and to continue to encourage breastfeeding as psycho-social variables associated with eating behaviours as likely to be related to preference for more nutritious foods. Furthermore, in consideration of the bi-directional relationship between children’s eating behaviour traits and parent feeding strategies, as previously discussed, these findings again highlight the need to support parents in understanding the intermediary role of eating behaviours in obesity development and in implementing feeding strategies appropriate to their child’s needs. Vandeweghe, et al., (2016) exemplify this potential by showing children high in reward sensitivity responded strongest to rewards to get them to try disliked vegetables, while children low in reward sensitivity respond best to verbal encouragement. [408] Finally, these findings have implications for future research to understand the psycho-social pathways contributing to eating behaviours, as may allow for better predictions of how they will interact under differing environmental circumstances.

Strengths and limitations

Whist studies have shown consistent relationships between eating behaviours traits and obesity development in children, few studies have aimed to determine differences in children’s eating behaviour traits based on psycho-social variables reflective of more ‘stressful’ life circumstance. This study makes important contributions in this regard, which assists in better understand the aetiology of childhood overweight and obesity. Of the few studies available, Dubios and colleagues (2007), have similarly shown that ‘overeating’ is related to single-parent family status, lower family income, income insufficiency, and having overweight or obese parents, in a longitudinal study (at 2.5, 3.5 and 4.5 years). [63] The present study extends on this by examining a broader range of eating behaviour traits, as captured in the CEBQ, and by examining a broader range of psycho-social variables.

While this study is limited in that it is cross sectional in nature, the large and diverse sample of participants is a noteworthy strength. All states in Australia have been represented in this sample, although comparably to national data Victoria, New South Wales and Northern Territory are slightly under represented ([sample v national] 17.7% V 25.0%, 25.2% V 32%, and 0.5% V 1.02%, respectively), while Queensland, Australian Capital Territory, Western Australia, Tasmania and South Australia are slightly over represented ([sample v national] 30% V 20.1%, 2.9% V 1.64%, 12.5% V 10.89%, 3% V 2.17% and 8.4% V 7.1%, respectively). [409] Rates of single parents in this study are similarly comparable to the 15% reported in national data, whilst distribution of participants in the high and middle income groups in this study are similar, low income families are underrepresented. [235]

The sample in this study is further likely to be comparable to national samples as, once cases of 'unlikely' anthropometric data were removed, rates of overweight and obese children in this study were similar to those reported in national data of between 18% - 23%, particularly rates reported in Australian children age 4 -5 years of 15.2% overweight and 5.5% obese. Rates of underweight children in this sample (n= 22.4%) however are likely over-represented compared with national data (n=7.55%), which similarly reduced rates of normal weight children in this sample (n=59.9%) compared with nations data (67.75%). [10] While it is possible that parents under-reported their child's weight, as is common, it is also possible that parents of underweight children are seeking support through online platforms, as was the recruiting process for this study, thus were more likely to self-enrol. [410] Additionally, parents were not asked to identify if they were the primary caregiver for the child or if the child resided with them, which could bias the data reported as well as its interpretation. Measuring concordance/discordance could be a direction for future research to examine this further.

Although there is no standard method of identifying IBV's, the methods applied in this study is considered to be highly appropriate and a quality feature of this study given that it has been reported that approximately 41% of large epidemiological studies did not address BIV's at all. [382] Based on the method of detecting BIV's used in this study, 18.5% of the initial sample were excluded. This rate is similar to that reported in a study of children 2 – 5 years (20.5% - 16.5% implausible), based on parent reported data, although other studies have reported much lower rates (7.9% - 9.7%). [388, 389] Limited data availability makes comparison difficult as does no standard method of reporting BIV.

Similar to what has been reported in other studies, misreporting of anthropometric data was higher in boys, although, contrary to other studies implausible data were higher in younger children. [390, 391]

4.1.3.5 Conclusion

This study makes a unique contribution to current understanding of eating behaviour traits in obesity status in early childhood in Australia. Eating behaviour traits, particularly food responsiveness and satiety responsiveness, are associated with BMI outcomes in early childhood and thus may prove a useful, measurable, intermediary marker of obesity risk. In exploring this prospect further, this study gives valuable insight into psycho-social variables associated with eating behaviour traits from which to speculate underlying pathways to obesity development, namely sleep duration, breastfeeding and parents stress levels. Better understanding of these underpinning pathways may assist in predicting how these traits manifest and interact in different environmental circumstance, thus better identifying and understanding high risk individuals, and better informing intervention strategies which may be effective in obesity prevention.

4.1.4 Family food environments in Australia and children's eating behaviours

4.1.4.1 Aim

While the previous section ascertained evidence of the relationship between children's eating behaviours, psycho-social variables and obesity status, given the expected importance of environmental factors in influencing these relationships, as consistent with the behavioural susceptibility theory, the following section extends on these preliminary findings by providing a thorough descriptive *picture* of the FFE's of Australian children during early childhood and exploring differences in these environments based on children's eating behaviours. Exploring the inter-relationships between children's eating behaviours and FFE variable provides important information regarding application of the behavioural susceptibility theory and provides valuable evidence to inform subsequent, refined analysis of these data.

4.1.4.2 Included measures

Measures included within this section are derived from survey 1 as detailed in section 3.2.4, including:

- Child BMIz and BMI category
- Parent BMI
- Children's eating behaviours (measured through the CEBQ [35, 67])
- FFE variables
    - Parent feeding practices (measured through the FPSQ-28 [243, 244]),
    - The frequency of family meals,
    - Parent's nutrition knowledge,
    - Parent's nutrition-related beliefs,
    - Parent's cooking skills and shopping skills
    - Availability fruit and vegetables within the home
    - Home resources (cooking facilities, food storage facilities)
    - Use of TV/electronic devices during meals
- Psycho-social variables (child age, gender, parent/respondent gender, single parent status, income, state and region of residency, sleep duration, breastfeeding history, parent's depression, anxiety and stress [measured through the DASS-21 [373]]).

4.1.4.3 Method

Descriptive data reflecting the FFE for the sample were produced for all variables using the data available from 1186 participants. Data from the sub-sample of 977 children, as described in table 8 (section 4.1.2.3), were used for further analysis to determine differences in FFE based on eating behaviours.

To examine whether CEBQ sub-scales differ based on categorical FFE variables (cooking skills, shopping skills, availability fruit and vegetables, cooking facilities, food storage facilities, use of TV/electronic devices during meals, individual health beliefs) a one-way between-groups multivariate analysis of variance (MANOVA) was performed with CBEQ sub-scales as dependent variables. Inter-covariance matrix was initially examined to determine the robustness of MANOVA for the current data. Box's M and Pillai's Trace for each independent variable was examined for significance, and homogeneity of variance assumption examined with Levene's F tests. In accordance with guidelines from Howell, (2009), Leven's test that fails significance tests (e.g. $p>0.05$), was examined for robustness based on the largest standard deviations being no more than four times the size of the corresponding smallest standard deviation. [411] Finally, a series of one-way ANOVA's on each of the CEBQ sub-scales was conducted as a follow-up test to the MANOVA, and post-hoc contrasts (LSD) performed. [7]

Pearson's correlation was conducted between continuous FFE variables (FPSQ sub-scales, total nutrition knowledge, total nutrition beliefs, total frequency of family meals) and CEBQ sub-scales. Where significant, stepwise regression, controlling for covariates as identified in section 4.1.3, was conducted to examine associations between significant FFE variables and CEBQ sub-scales. [89] Coefficients, confidence intervals and mean scores were inspected to check the direction and pattern of the association. Hypotheses assumed a 0.05 significance level and a two-sided alternative hypothesis. All analyses were carried out using SPSS v24 (SPSS Inc., Chicago, IL, USA).

4.1.4.4 Results

4.1.4.4.1 Family food environment descriptive results

Use of TV and electronic devices during meals

Sixty percent (60%) of parents responded 'yes' or 'sometime' to family use of TV during meals. Additionally, 10.8% of parents responded 'yes' or 'sometimes' to child use of electronic devices during meals and 32% of parents responded 'yes' or 'sometimes' to adult use electronic devices during meals (table 17).

Table 17: Television and electronic device use during meals - % (95% CI) (n=1186)			
	No	**Sometimes**	**Yes**
Family use of TV during meals	40.1% (37.3 – 42.9)	45.4% (42.5 – 48.2)	14.6% (12.6 – 16.6)
Child use devices during meals	89.2% (87.4 – 91.0)	8.3% (6.7 – 9.8)	2.5% (1.6 – 3.4)
Adult use of devices during meals	68.0% (65.4 – 70.7)	27.4% (24.9 – 29.9)	4.6% (3.4 – 5.8)

Cooking and home resources:

Cooking and food storage facilities within the home were considered suitable (*strongly agree*) by 91.7% and 90.7% of parents, respectively, and 76.6% of parents strongly agree they had sufficient money to buy food each week. Almost all parents (92.7%) reported that they *always* had fruit and vegetables available within the home and no parents reported fruit and vegetables were never available (table 18).

Table 18: Cooking and home resources - % (95% CI) (n=1186)				
	Strongly disagree	**Disagree**	**Agree**	**Strongly agree**
The family home has suitable cooking facilities	1.9% (1.1 – 2.7)	1.0% (0.4 – 1.6)	5.3% (4.0 – 6.6)	91.7% (90.1 – 93.3)
The family home has suitable food storage	1.9% (1.1 – 2.7)	1.6% (0.9 – 2.3)	5.8% (4.5 – 7.1)	90.7% (89.0 – 92.4)

	Not usually	Sometimes	Mostly	Always
The family home has enough money to buy food eat week	1.9% (1.1 – 2.7)	5.1% (3.8 – 6.4)	16.5% (14.4 – 18.6)	76.6% (74.2 – 79.0)
How often are fruits and vegetable available within the home?	0%	1% (0.4 – 1.6)	6.2% (4.8 – 7.5)	92.7% (91.2 – 94.2)

Confidence in cooking and shopping:

In rating their own cooking and grocery shopping skills, 91.5% and 96.6% of parents reported their cooking skills and shopping skills as *good* or *very good*, respectively (table 19).

Table 19: Parents personal skills - % (95% CI) (n=1186)				
	very poor	**poor**	**good**	**very good**
How would you rate your shopping skills?	0.2% (-0.1 - 0.5)	3.3% (2.3 – 4.3)	31.5% (28.9 – 34.1)	65.1% (62.4 – 67.8)
How would you rate your cooking skills?	0.8% (0.3 – 1.3)	7.8% (6.3 – 9.3)	45.3% (42.5 – 48.1)	46.2% (43.4 – 49.0)

Health beliefs:

Fifty-one per cent (51.5%) of parents *agreed* or *strongly agreed* that 'healthy eating was expensive,' 16.4% of parents *agree or strongly agree* that 'it takes too long to prepare a healthy meal,' 6.4% of parents *agree* or *strongly agree* that 'healthy food doesn't taste good,' and 71.5% of parents rated nutrition for their family as *'important*' (table 20).

Table 20: Health beliefs - % (95% CI) (n=1186)				
	Strongly disagree	**Disagree**	**Agree**	**Strongly agree**
Eating healthy is expensive	19.8% (17.5 – 22.1)	28.7% (26.1 – 31.2)	35.9% (33.2 – 38.6)	15.6% (13.5 – 17.7)
It takes too long to prepare a healthy meal	48.1% (45.3 – 51.0)	35.5% (32.8 – 38.2)	14.1% (12.1 – 16.1)	2.3% (1.5 – 3.2)
Healthy Food doesn't taste good	71.5% (68.9 – 74.1)	22.1% (19.7 – 24.5)	5.3% (4.0 – 6.6)	1.1% (0.5 – 1.7)
	Somewhat unimportant	**Neither**	**Somewhat important**	**Important**
Healthy eating is important	0.4% (0.0 – 0.8)	1.9% (1.1 – 2.7)	26.2% (23.7 – 28.7)	71.5% (68.9 – 74.1)

Sources of nutrition information:

The main source of nutrition information identified by parents was internet/websites, with 81.8% of parents obtaining information from these sources. Friends and family were the second most common source of nutrition information for parents (42.7%), followed by government material such as the Australian Dietary Guidelines (ADG) (38.4%) (table 21).

Table 21: Sources of nutrition knowledge - % (95% CI) (n=1186)	
Internet/websites	81.8% (79.6 – 84.0)
Government material (e.g. Australian Dietary Guidelines)	38.4% (35.6 – 41.2)
Magazines, newspapers, blogs	29.7% (27.1 – 32.3)
Nutrition textbooks or research journals	18.3% (16.1 – 20.5)
Radio or TV programs	9.5% (7.8 – 11.2)
Family Doctor	26.7% (24.1 – 29.2)
Child health nurse	28.8% (26.2 – 31.4)
Dietitian	16.5% (14.4 – 18.6)
Naturopath/ fitness trainer	14.1% (12.1 – 16.1)
Family/ friends/kinship group	42.7% (40.0 – 45.5)
Other	11.0% (9.2 – 12.8)

Grocery shopping and meal preparation responsibilities

Seventy-five per cent (75%) of responding parents reported that they were responsible for meal preparation, while 23.4% reported that both parents were responsible. Similarly, 77.9% of responding parents reported that they were responsible for grocery shopping, while 19.2% reported that both parents were responsible (table 22).

Table 22: Grocery shopping and meal preparation responsibilities - % (95% CI) (n=1186)				
	I am mostly responsible	Another parent/adult is responsible	Both parents/ adults share responsibility	Other
Who is responsible for meal preparation	75% (72.5 – 77.5)	3.7% (2.6 – 4.8)	23.4% (21.0 – 26.0)	0%
Responsible for grocery shopping	77.9% (75.5 – 80.2)	3.6% (2.5 – 4.7)	19.2% (17.0 -21.4)	0%

Nutrition knowledge, beliefs, feeding practices, stress, depression and anxiety

Participants scored a mean of 11.1 (out of 13; SD 1.16; 85.9%) on the total nutrition knowledge scale. The mean score for nutrition related beliefs was 6.84 (SD 1.99), with a range of 4 – 14. Participants reported a mean of 13.5 (SD 4.5; out of a possible 21) family meals per week, the majority of which were dinners (mean 6.1 family dinners, SD 1.68). On Likert scales from 1 (Never) to 5 (always), parents reported a moderate use of food as a reward for eating and food as a reward for behaviours (mean 2.12 [SD 0.74], 2.17 [SD 0.81], respectively), and slightly higher use of persuasive feeding techniques (mean 3 [SD 0.76]), covert restriction (mean 3.16 [SD 0.94]), overt restriction (mean 3.45 [SD 0.85]), structured meal timing (mean 3.33 [SD 0.44]), and structured meal setting (mean 3.08 [SD

0.47]). Parent's depression, anxiety and stress scores corresponded with *normal* ranges (according to standard DASS scoring; not presented) for 94.8%, 98.1% and 98.4% of participants, respectively (table 23).

Table 23: Continuous family food environment variables (n=1186)	Mean (SD)
Total Nutrition knowledge	11.17 (1.16)
Total Nutrition related beliefs	6.85 (1.99)
Parent feeding strategies	
Single family meal (single item)[a]	5
Reward for eating[a]	2.12 (0.74)
Reward for behaviour[a]	2.17 (0.81)
Persuasive feeding[a]	3.00 (0.76)
Covert restriction[a]	3.16 (0.94)
Overt restriction[a]	3.45 (0.85)
Structured meal setting[a]	3.33 (0.44)
Structured meal timing[a]	3.08 (0.47)
Frequency family meals (total)	13.45 (4.5)
Breakfast	4.16 (2.46)
Lunch	3.19 (2.07)
Dinner	6.10 (1.68)
DASS-21	
Depression[b]	5.69 (3.37)
Anxiety[b]	1.65 (1.83)
Stress[b]	2.88 (3.24)
a.FPSQ-28 Sub Scales (Jansen, et al. 2016)	
b. DASS-21 Sub Scales (Szabo, 2010)	

4.1.4.4.2 Relationship between family food environment variables and CEBQ sub-scales

Parent's personal skills

In MANOVA, enjoyment of food increased with cooking skills, accounting for ~2% of the variance in this eating behaviour, while food fussiness decreased with cooking skills, accounting for ~2% of the variance in this eating behaviour (p=0.002 and p=0.002, respectively). Enjoyment of food generally increased with shopping skills, accounting for 3% of the variance, while food fussiness and slowness in eating decreased, accounting for ~4% and ~2% of the variance in these eating behaviours, respectively (p=0.000, p=0.000, and p=0.002, respectively) (table 24).

Table 24: Parent's personal skills by eating behaviour – MANOVA (n=977)					MANOVA P	Partial n^2
Cooking skills[1]	**Very Poor**	**Poor**	**Good**	**Very Good**		
Enjoyment of food[a]	3.28 (1.31)	3.76 (.77)	3.84 (.69)	3.96 (.71)	.002	.016
Food fussiness[a]	3.24 (1.05)	3.06 (.93)	2.89 (.94)	2.71 (.91)	.002	.015
Shopping skills[2]	**Very Poor**	**Poor**	**Good**	**Very Good**		
Enjoyment of food[a]	2.38 (1.94)	3.58 (.81)	3.77 (.70)	3.96 (.70)	.000	.030
Food fussiness[a]	3.67 (.00)	3.49 (.99)	3.06 (.95)	2.71 (.90)	.000	.039
Slowness in eating[a]	4.50 (.71)	3.49 (.90)	3.15 (.69)	3.15 (.67)	.002	.015

Post-hoc analysis (LSD), indicated significant differences:

(EF= enjoyment of food; FF= food fussiness; SE= slowness in eating; VP=very poor; VG = very good; SA = strongly agree; SD = strongly disagree)

1. EF - 'VP' and: 'good' (p=.018), 'VG' (p=.004); 'VG' and: 'poor' (p=.025), 'good' (p=.013); FF, 'VG' and: 'poor' (p=.003), 'good' (p=.005);

2. EF - 'VP' and: 'poor' (p=.020), 'good' (p=.006), 'VG' (p=.002); 'VG' and: 'poor' (p=.004), 'good' (p=.000); FF - 'poor' and: 'good' (p=.006), 'VG' (p=.000); 'good' and 'VG' (p=.000); SE - 'VP' and: 'poor' (p=.045), 'good' (p=.006), 'VG' (p=.006); 'poor' and: 'good' (p=.009),'VG' (p=.008);

(p=.003); SE - 'mostly' and: 'sometimes' (p=.001), 'always' (p=.001);

a. CEBQ Sub Scales (Wardle, et al. 2001)

Cooking and home resources

Food fussiness generally decreased with suitability of cooking facilities, accounting for 0.8% of the variance (p=0.048). Enjoyment of food and food fussiness differed with suitability of food storage facilities but no clear direction between response categories was seen (p=0.036 and p=0.035, respectively). Food fussiness and food responsiveness decreased with sufficient money to buy food each week, accounting for 1% and ~2% of the variance in these eating behaviours, respectively (p=0.018 and p=0.000, respectively). Enjoyment of food and slowness in eating generally increased with availability of fruit and vegetables within the home, explaining ~2% and ~1% of the variance in these eating behaviours, respectively (p=0.000 and p=0.003, respectively), while food fussiness and food responsiveness generally decreased, explaining ~1% of the variance in each of these eating behaviours (p=0.000 and p=0.001, respectively) (table 25).

Table 25: Cooking and home resources – MANOVA (n=977)					MANOVA P	Partial n^2
The family home has suitable cooking facilities[1]	**Strongly disagree**	**Disagree**	**Agree**	**Strongly agree**		
Food fussiness[a]	2.75 (1.15)	3.33 (1.32)	3.07 (1.06)	2.80 (.91)	.048	.008
The family home has suitable food storage [2]	**Strongly disagree**	**Disagree**	**Agree**	**Strongly agree**		
Enjoyment of food[a]	3.86 (.99)	4.06 (.66)	3.63 (.87)	3.90 (.70)	.036	.009
Food fussiness[a]	2.61 (1.10)	2.66 (.94)	3.15 (.97)	2.81 (.92)	.035	.009

The family home has enough money to buy food eat week[3]	**Not Usually**	**Sometimes**	**Mostly**	**Always**		
Food fussiness[a]	2.83 (1.20)	2.91 (1.01)	3.03 (.99)	2.78 (.90)	.018	.010
Food responsiveness[a]	2.97 (1.05)	2.80 (.89)	2.64 (.81)	2.49 (.72)	.000	.018
How often are fruits and vegetable available within the home?[4]	**Never**	**Sometimes**	**Mostly**	**Always**		
Enjoyment of food[a]	0.0	2.92 (.82)	3.72 (.90)	3.91 (.75)	.000	.021
Food fussiness[a]	0.0	3.89 (.98)	3.21 (1.12)	2.79 (.91)	.000	.024
Food responsiveness[a]	0.0	2.38 (.82)	2.82 (.90)	2.52 (.74)	.001	.009
Slowness in eating[a]	0.0	3.94 (.95)	3.16 (.58)	3.15 (.69)	.003	.012

Post-hoc analysis (LSD), indicated significant differences:
(EF= enjoyment of food; FF= food fussiness; SE= slowness in eating; FR = food responsiveness; SA = strongly agree; SD = strongly disagree)
1. FF – SA and: disagree (p=0.050), agree (p=0.041)
2. EF- 'agree' and: 'disagree' (p=.033), 'SA' (p=.006); FF - 'SA' and: 'disagree' (p=.050), 'agree' (p=.041);
3. FF - 'mostly' and 'always' (p=.002); FR - 'always' and: 'not usually' (p=.008), 'sometimes' (p=.005), 'mostly' (p=.021);
4. EF - 'sometimes' and: 'mostly' (p=.002), 'always' (p=.000); FF - 'sometimes' and: 'mostly' (p=.040), 'always' (p=.000); 'mostly' and 'always' (p=.001). FR - 'mostly' and 'always'
a. CEBQ Sub Scales (Wardle, et al. 2001)

Use of television and electronic devices during meals

Enjoyment of food decreased with family use of TV during meals, explaining ~1% of the variance in this eating behaviour (p=0.003), while food fussiness, satiety responsiveness and slowness in eating increased, explaining ~2%, ~1% and ~1% of the variance in these eating behaviours, respectively (p=0.000, p=0.028 and p=0.018, respectively). Enjoyment of food decreased with child use of electronic devices during meals, explaining ~3% of the variance in this eating behaviour (p=0.000), while food fussiness and satiety responsiveness increased, explaining ~2% and ~1% of the variance in these eating behaviours, respectively (p=0.000 and p=0.004, respectively). Slowness in eating increased with adult use of electronic devices during meals, explaining ~1% of the variance in this eating behaviour (p=0.021) (table 26).

Table 26: Television and electronic device use during meals by eating behaviour – Mean (SD) (n= 977)				MANOVA P	Partial n[2]
Family TV use during meals[1]	**Yes**	**Sometimes**	**No**		
Enjoyment of food[a]	3.72 (0.78)	3.87 (0.70)	3.96 (0.69)	.003	.012
Food fussiness[a]	3.02 (1.11)	2.90 (0.88)	2.66 (0.90)	.000	.022
Satiety responsiveness[a]	3.24 (0.63)	3.15 (0.59)	3.08 (0.50)	.028	.007
Slowness in eating[a]	3.27 (0.67)	3.19 (0.69)	3.09 (0.69)	.018	.008
Child use of devices during meals[2]	**Yes**	**Sometimes**	**No**		
Enjoyment of food[a]	3.17 (0.70)	3.81 (0.74)	3.91 (0.70)	.000	.025
Food fussiness[a]	3.67 (0.80)	2.99 (0.92)	2.79 (0.92)	.000	.024
Satiety responsiveness[a]	3.50 (0.67)	3.21 (0.55)	3.12 (0.59)	.004	.011
Adult use of devices during meals[3]	**Yes**	**Sometimes**	**No**		
Slowness in eating[a]	3.34 (0.69)	3.23 (0.68)	3.12 (0.69)	.021	.008

Post-hoc analysis (LSD), indicated significant differences:
(EF= enjoyment of food; FF= food fussiness; SE= slowness in eating; FR= food responsiveness; SR = satiety responsiveness)
1. EF - 'Yes,' and: 'No' (p=.001), 'Sometime' (P=.026); FF 'No' and: 'Sometimes' (p=.000), 'Yes' (p=.000); SR - 'No' and 'Yes' (p=.010); SE - 'No' and: 'Sometimes' (p=.037), 'Yes' (P=.037);
2. EF - 'Yes,' and: 'No' (p=.000), 'Sometime' (P=.000); FF - 'Yes' and: 'No' (p=.000), 'Sometimes' (p=.002); SR - 'Yes' and: 'No' (p=.002), 'Sometimes' (p=.040);
3. SE - 'No' and: 'Sometime' (p=.031), 'Yes' (p=.041);
a. CEBQ Sub Scales (Wardle, et al. 2001)

<u>Parent's nutrition beliefs</u>

Enjoyment of food decreased with the belief that 'healthy eating is expensive', explaining ~1% of the variance in this eating behaviour (p=0.016), while food fussiness, food responsiveness and satiety responsiveness increased, explaining 2%, ~1% and ~1% of the variance in these eating behaviours, respectively (p=0.000, p=0.003 and p=0.036, respectively). Enjoyment of food decreased with the belief that 'healthy food takes too long to prepare,' explaining ~2% of the variance (p=0.001), while food fussiness and food responsiveness increased, explaining ~3% and ~2% of the variance, respectively (p=0.000 and p=0.000, respectively). Enjoyment of food decreased with the belief 'healthy food doesn't taste good', explaining ~4% of the variance (p=0.000), while food fussiness and food responsiveness increased, explaining ~5% and ~2% of the variance, respectively (p=0.000 and p=0.001, respectively). Enjoyment of food and satiety responsive differed significantly for the belief that 'healthy eating is important,' explaining ~2% and ~1% of the variance (p=0.000 and p=0.037, respectively), but no clear direction of trend between categories was seen. Food fussiness decreased with the belief 'healthy eating is important,' explaining ~2% of the variance (p=0.000) (table 27).

Table 27: Nutrition related beliefs by eating behaviour – MANOVA (n=977)				MANOVA P	Partial n^2
Eating healthy is expensive[1]	**Strongly disagree**	**Disagree**	**Agree**		
Enjoyment of food[a]	4.00 (0.74)	3.86 (0.68)	3.90 (0.84)	3.75 (0.84)	.016
Food fussiness[a]	2.62 (0.96)	2.80 (0.87)	2.84 (0.86)	3.07 (1.11)	.000
Food responsiveness[a]	2.42 (0.75)	2.47 (0.71)	2.59 (0.73)	2.69 (0.90)	.003
Satiety responsiveness[a]	3.08 (0.60)	3.15 (0.56)	3.11 (0.54)	3.26 (0.72)	.036
It takes too long to prepare a healthy meal[2]	**Strongly disagree**	**Disagree**	**Agree**		
Enjoyment of food[a]	4.00 (0.71)	3.85 (0.65)	3.71 (0.82)	3.75 (0.89)	.001
Food fussiness[a]	2.66 (0.92)	2.90 (0.85)	3.12 (1.05)	3.00 (1.15)	.000
Food responsiveness[a]	2.43 (0.74)	2.59 (0.73)	2.71 (0.83)	2.73 (0.86)	.000
Healthy food doesn’t taste good[3]	**Strongly disagree**	**Disagree**	**Agree**		
Enjoyment of food[a]	4.00 (0.70)	3.72 (0.67)	3.49 (0.86)	3.72 (0.95)	.000
Food fussiness[a]	2.70 (0.89)	3.08 (0.93)	3.40 (0.92)	3.24 (1.05)	.000
Food responsiveness[a]	2.49 (0.75)	2.62 (0.70)	2.84 (0.96)	2.76 (1.03)	.001
Healthy eating is important[4]	**Unimportant**	**Somewhat Unimportant**	**Somewhat important**		
Enjoyment of food[a]	3.81 (0.99)	3.38 (0.93)	3.77 (0.67)	3.94 (0.72)	
Food fussiness[a]	3.04 (1.40)	3.39 (1.04)	2.99 (0.90)	2.75 (0.93)	
Food responsiveness[a]	2.80 (1.04)	2.40 (0.96)	2.65 (0.75)	2.50 (0.75)	

Post-hoc analysis (LSD), indicated significant differences:

(SA = strongly agree; SD = strongly disagree; SU = somewhat unimportant; SI = somewhat important)

1. EF- ‘SD’ and: ‘disagree’ (p=.044), ‘SA’ (p=.002); ‘agree’ and ‘SA’ (p=.041); FF - ‘SD’ and: ‘disagree’ (p=.042), ‘agree’ (p=.009), ‘SA’ (p=.000); ‘SA’ and: ‘disagree’ (p=.004), ‘agree’ (p=.010); FR - ‘SD’ and: ‘agree’ (p=.016), ‘SA’ (p=.002); ‘disagree’ and: ‘agree’ (p=.049), ‘SA’ (p=.005); SR - ‘SA’ and: ‘SD’ (p=.006), ‘agree’ (p=.012);

2. EF - ‘SD’ and: ‘disagree’ (p=.017), ‘agree’ (p=.000); ‘disagree’ and ‘agree’ (p=.049); FF - ‘SD’ and: ‘disagree’ (p=.000), ‘agree’ (p=.000); FR - ‘SD’ and: ‘disagree’ (p=.004), ‘agree’ (p=.000);

3. EF - ‘SD’ and: ‘disagree’ (p=.000), ‘agree’ (p=.000); FF - ‘SD’ and: ‘disagree’ (p=.000), ‘agree’ (p=.000); ‘disagree’ and ‘agree’ (p=.019); FR - ‘SD’ and: ‘disagree’ (p=.024), ‘agree’ (p=.001); ‘disagree’ and ‘agree’ (p=.046);

4. EF - ‘SU’ and: ‘SI’ (p=.049), ‘important’ (p=.003); ‘SI’ and ‘important’ (p=.001). FF - ’important’ and: SU’ (p=.008), ‘SI’ (p=.000); FR ‘SI’ and ‘important’ (p=.006).

a. CEBQ Sub Scales (Wardle, et al. 2001)

Relationship between continuous FFE variables and CEBQ sub-scales

Based on results from correlation analysis (table 28), stepwise regression was conducted between CEBQ sub-scales and continuous FFE variables, controlling for covariates.

Table 28: Pearson’s correlations between CEBQ sub-scales and continuous FFE variables (n=977)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Enjoyment of food[a]	1																
2. Food fussiness[a]	-.651**	1															
3. Food responsiveness[a]	.333**	-.072*	1														
4. Satiety responsiveness[a]	-.541**	.436**	-.401**	1													
5. Slowness in eating[a]	-.361**	.291**	-.200**	.403**	1												
6.Child BMIz	.068*	-.072*	.096**	-.105**	ns	1											
7.Parent BMI (kg/m^2)	ns	ns	ns	.128**	ns	.069*	1										
8. Family meal[b]	.324**	-.455**	.118**	-.182**	-.068*	ns	ns	1									
9. Reward for eating[b]	-.124**	.255**	.224**	ns	.130**	ns	ns	ns	1								
10. Reward for behaviour[b]	-.078*	.233**	.264**	ns	ns	ns	ns	-.115**	.538**	1							
11. Persuasive feeding[b]	-.165**	.278**	.136**	ns	.180**	ns	ns	ns	.467**	.327**	1						
12. Covert restriction[b]	.112**	-.130**	ns	-.066*	ns	ns	ns	.129**	-.114**	-.195**	-0.034	1					
13. Overt restriction[b]	ns	.192**	.260**	ns	.064*	.063*	ns	-.101**	.266**	.269**	.218**	.089**	1				
14. Structured mealsetting[b]	.129**	-.102**	.085**	-.172**	-.082**	ns	ns	.169**	.079*	-.114**	.193**	ns	ns	1			
15. Structured mealtiming[b]	ns	-.064*	.070*	-.081*	ns	ns	ns	.150**	.071*	ns	.154**	ns	.093**	.324**	1		
16. Nutrition knowledge	.074*	ns	ns	ns	-.075*	ns	ns	ns	ns	ns	-.077*	ns	ns	ns	ns	1	
17.Nutrition beliefs	-.185**	.240**	.169**	.072*	.063*	ns	.235**	-.157**	.206**	.282**	.155**	-.221**	.149**	-.087**	ns	-.088**	1
18. Frequency of family meals	.167**	-.157**	ns	-.126**	ns	ns	ns	.238**	-.084**	-.096**	ns	.071*	-.100**	.108**	ns	ns	-.134**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
a. CEBQ Sub Scales (Wardle, et al. 2001)
b. FPSQ-28 Sub Scales (Jansen, et al. 2016)

As shown in table 29, after controlling for covariates which explained 4.4% of the variance, enjoyment of food was positively associated with single family meals (B=0.210, p=0.000), explaining 9.2% of the variance, the frequency of family meals (B=0.012, p=0.013), explaining 0.7% of the variance, structured meal setting (B=0.019, p=0.027), explaining 0.4% of the variance, and total nutrition knowledge (B=0.037, p=0.036), explaining 0.4% of the variance; and was negatively associated with persuasive feeding (B=-0.131, p=0.000), explaining 1.7% of the variance, and total nutrition related beliefs (B=-0.026, p=0.027), explaining 0.5% of the variance (table 29).

After controlling for covariates which explained 5.6% of the variance, food fussiness was positively associated with reward for eating (B=0.128, p=0.001), which explained 1.3% of the variance, persuasive feeding (B=0.221, p=0.000), which explained 5.3% of the variance, overt restriction (B=0.080, p=0.009), which explained 0.4% of the variance, and total nutrition related beliefs (B=0.043, p=0.002), which explained 0.8% of the variance; and was negatively associated with single family meals (B=-0.409, p=0.000), which explained 18.6% of the variance, and structured meal setting (B=-0.023, p=0.02), which explained 0.4% of the variance (table 29).

After controlling for covariates, which explained 3.6% of the variance, food responsiveness was positively associated with reward for behaviour (B=0.180, p=0.000), overt restriction (B=0.175, p=0.000), a single-family meal (B=0.153, p=0.000), and total nutrition related beliefs (B=0.047, p= 0.000), which explain 6.2%, 3.4%, 2.8% and 1.2% of the variance, respectively (table 29).

After controlling for covariates, which explained 4.4% of the variance, satiety responsiveness, was positively associated with persuasive feeding (B=0.088, p= 0.001), which explained 0.7% of the variance; and negatively with a single family meal (B=-0.083, p=0.000), a structured meal setting (B=-0.029, p= 0.000), the frequency of family meals (B=-0.011, p=0.009), and food as a reward for behaviour (B=-0.056, p=0.021), which explained 2.7%, 1%, 0.6% and 0.5% of the variance respectively (table 29).

After controlling for covariates, which explained 4.2% of the variance, slowness in eating, was positively associated with persuasive feeding (B=0.168, p=0.000), which explained 2.6% of the variance, and negatively associated with a structured meal setting (B=-0.023, p=0.005), which explained 0.8% of the variance (table 29).

Table 29: Continuous variables associated with eating behaviours in stepwise regression (n=977)										
	Enjoyment of food[a]		**Food fussiness[a]**		**Food responsiveness[a]**		**Satiety responsiveness[a]**		**Slowness in eating[a]**	
Covariates	B (SE)	B (P Value)	B (SE)	B (P Value)	B (SE)	B (P Value)	B (SE)	B (P Value)	B (SE)	B (P Value)
Family meals	.210 (.025)	.266 (.000)	-.409 (.029)	-.397 (.000)	.153 (.025)	.182 (.000)	-.083 (.021)	-.127 (.000)		
Reward for eating[b]			.128 (.039)	.102 (.001)						
Reward for behaviour[b]					.180 (.029)	.194 (.000)	-.056 (.024)	-.077 (.021)		
Persuasive feeding[b]	-.131 (.029)	-.139 (.000)	.221 (.038)	.181 (.000)			.088 (.027)	.113 (.001)	.168 (.030)	.185 (.000)
Covert restriction[b]										
Overt restriction[b]			.080 (.031)	.074 (.009)	.175 (.027)	.198 (.000)				
Structured meal setting[b]	.019 (.008)	.071 (.027)	-.023 (.010)	-.068 (.020)			-.029 (.007)	-.131 (.000)	-.023 (.008)	-.092 (.005)
Total nutrition knowledge	.037 (.017)	.062 (.036)								
Total nutrition-related beliefs (inverse score)	-.026 (.012)	-.072 (.027)	.043 (.014)	.091 (.002)	.047 (.013)	.123 (.000)				
Frequency of family meals	.012 (.005)	.076 (.013)					-.011 (.004)	-.084 (.009)		
R^2 Covariates (Step 1)	.044		.056		.036		.044		.042	
Final Model R^2	.174		.324		.171		.099		.075	
F for model	14.51		32.89		16.62		8.15		7.84	
a. CEBQ Sub Scales (Wardle, et al. 2001)										
b. FPSQ-28 Sub Scales (Jansen, et al. 2016)										

4.1.4.5 Discussion

This section adds a great deal of descriptive data to what is currently known about FFE's of children during early childhood in Australia which aids in understanding of the ecological contexts in which obesity may occur. While a high number of analysis conducted in this section increases the risk of a type 1 error (as discussed in detail in section 5.1.2), this section provides some insight into the relationship between FFE's and children's eating behaviours by examining a broad scope of variables conceptualized within the interpersonal and micro-environment levels of the socio-ecological model. These contributions to the literature are discussed in turn below.

Family food environment descriptive characteristics

Data reflecting the FFE of children in this study generally appears consistent with what has been suggested in the literature to be health promoting. For instance, participating in the reported 13.5 family meals per week is likely to promote healthy outcomes as suggested by Hammons, et al., (2011), who showed that children (2.8 – 17.3 years) who shared three of more family meals per week were at increased odds for healthy eating (OR=1.24 [95% CI: 1.13–1.37]), and reduced odds of overweight (OR=0.88 [95% CI: 0.81–0.97]), eating unhealthy food (OR=0.80 [95% CI: 0.68–0.95]) and disordered eating (OR=0.65 [95% CI: 0.58–0.73]). [205]

Additionally, these data show reasonably high levels of parent nutrition knowledge, high levels of agreement that nutrition is *important,* adequate home resources (cooking and food storage facilities), and frequent availability of fruit and vegetables within the home. These factors are likely to have a positive influence on dietary intake of both parent and child to create a FFE that positively reinforces health behaviours. [224, 237, 303] Additionally, there is strong evidence that parents with greater food and nutrition knowledge, skills and self-efficacy (as reflected in high levels of cooking and grocery shopping skills) are less likely to have overweight or obese children. [223] Parent's nutrition related beliefs appear consistent with the findings of Vereecken, et al., (2010), who reported in a Flemish study that, among 862 parents of preschoolers, 75% disagreed that healthy food is less tasty, and 44% did not consider healthy food as more expensive, whereas 26% did find it more expensive. [412] The generalisability of this study to the current data set may, however, be limited.

Parents also generally reported levels of stress, depression and anxiety within normal ranges, which is likely to assist in role modelling healthy eating behaviours, support positive family functioning, and protect against the association between maternal stress and childhood obesity. [228, 413] Parents with lower levels of stress and depressive symptoms have been reported to use less controlling feeding practices, as somewhat reflected in the moderate use of controlling feeding practices seen in this analysis. [414, 415]

Feeding practice scores in these data appear comparable to those previously reported in a study of Australian mothers of children 2 years of age, with parents in both studies scoring highest on providing a single-family meal, a structured meal settings and structured meal timing which is likely to be health promoting by providing routine and predictability for children to learn healthful eating behaviours and value in meals as a family occasion. [20, 246, 252, 269] Moderate use of overt restriction and persuasive feeding practices were also reported which have been associated with poorer regulation of hunger and satiety, development of socio-cultural associations with restricted foods seen as favorable and desirable, and, has been linked with increased body mass. [188, 199, 246, 250, 252]

While only 10.8% of parents reported child use of electronic devices during meals, high rates of TV use by families (60%) during meals in these data are concerning given that use of TV during meals has been associated with disruptions to the bodies satiety signals and increased exposure to food advertising which shapes preferences for unhealthy foods. [12, 205, 210, 280, 290-292, 416-418] Food advertising and other forms of distraction while eating, are likely to be particularly problematic for individuals with susceptibility to food cue responsivity and disinhibited eating, such as those experiencing more stressful life circumstances and disadvantage, including low socio-economic, as previously discussed (section 2.2.3). [74, 98, 177, 180, 211]

<u>Relationship between family food environment variables and CEBQ sub-scales</u>

Keeping in mind the risk of type 1 error, on examining the difference in children's eating behaviours based on FFEs, satiety responsiveness appears to be least vulnerable to environmental influences. [89] This finding is somewhat consistent with the findings presented in section 4.1.3, whereby satiety responsiveness was associated with few psycho-social variables, thus suggesting a limited capacity to be altered within the FFE. Consistently, satiety responsiveness has been reported to be 72% heritability, while 59%

of food responsiveness, 84% of slowness in eating, 52% of food fussiness, and 53% of enjoyment of food are reported to be hereditable. [113, 195] This higher vulnerability of enjoyment of food, food fussiness and food responsiveness to environmental influences is reflected in the findings of this section, with 32.6%, 54.3% and 22.1% of variance in these eating behaviours cumulatively explained by the FFE variables examined, respectively. Comparably, only 8.2% of the variance in satiety responsiveness and 7.7% of the variance in slowness in eating was explained cumulatively by the variables included in these data. This perspective that satiety responsiveness is somewhat resistant to environmental influence is inconsistent with results from the follow up analysis of the NOURISH RCT, which showed that at 2 years and 3.5 years follow up, intervention children, compared with the control group, had higher satiety responsiveness (p=0.03 and p=0.04, respectively), as would confer an obesity ‘reducing’ risk. [307, 308] Interestingly, however, a reduction in food responsiveness was not seen in the NOURISH study until 3.5 years follow up (p = 0.04 [at 2 years follow up p=0.06]). [307, 308] As food responsiveness is believed to increase with child age, this finding could reflect the delayed emergence of this eating behaviours. The NOURISH RCT achieved these changes in children’s eating behaviours following an anticipatory guidance child feeding intervention, commencing when children were 4 – 7 months old, through which parents were encouraged to use responsive feeding practices. [307]

Consistent with this, parent’s feeding strategies appeared to account for a large amount of variance in children’s eating behaviours detected in this analysis. As a cross-sectional study the direction of this relationship cannot be assumed, however, it has been reported across the literature that a bi-directional association is likely to occur between child eating behaviours and feeding strategies implemented. [38, 201, 202] That is, while non-responsive feeding strategies such as use of food as a reward for eating and persuasive feeding, are likely to increase food fussiness, these feeding strategies are also likely to be implemented in response to parent’s perceptions of a child’s fussy tendencies. [201, 239, 297] Specifically, a recent study examining the bi-directional relationship between parent’s feeding practices and children’s eating behaviours at 2 years, 3.7 years and 5 years, used cross-lagged analysis to show that higher reward for behaviour (β=0.12, p=0.025) and lower covert restriction (β= −0.14, p=0.008) were prospectively associated with higher food responsiveness, while increased child satiety responsiveness was primarily prospectively associated with mother’s feeding practices (increased structured meal timing [β=0.11, p=0.038], overt restriction [β=0.14, p=0.010] and covert restriction [β=0.11, p=0.022]).

[259] The only exception was family meal setting, which was prospectively negatively associated with satiety responsiveness ($\beta=-0.11$, $p=0.035$). [259] Interestingly, covert restriction was not associated with any CEBQ sub-scales in this analysis.

In addition to food fussiness, non-responsive feeding strategies, have been seen to relate to increased food responsiveness and decreased enjoyment of food, as also consistent with the findings of this section and across the literature. [201, 239, 297] While decreases in enjoyment of food are undesirable, as previously discussed, increases in food responsiveness are likely to be particularly problematic, as associated with increased weight status and preference for non-core foods. [5, 7] With this in mind, overt restriction, as associated with food responsiveness and food fussiness, was also the only FFE variable correlated with child BMIz in this analysis. This inter-relationship between overt restriction, food fussiness and food responsiveness, and child BMIz, suggests the potential for a mediator relationship between these variables that warrants further investigation (section 4.1.5). It seems clear that parents need to be supported in understanding the potential vulnerability of eating behaviours to non-responsive and restrictive feeding strategies, as well as supported in adopting feeding strategies which promote a balance of food approach and food avoidance eating behaviours to support a healthy growth trajectory. [38, 307]

With this in mind, the lower than expected correlation between parent and child BMIz, based on expectations of shared gene and shared environments, may in part be explained by parent's use of non-responsive feeding strategies, which are considered to be aspects of non-shared environment and thus likely to have a differential impact on child weight and/or eating behaviours (see section 5.1.1). Similarly, and as consistent with the concepts of the behavioural susceptibility theory, it has been established in multiple sources that the strength of the correlation between parent and child weight increases with age, thus the young age of this sample could too contribute to explanations of the low correlation noted. [419, 420] Further to this, participants in this study were not asked to identify if they were genetically related to the child and BMI data were collected for only one parent, which, given sex specific correlations between parent and child weight, could also contribute to the results seen. [419, 420]

On a similar note, the correlation detected between parent's BMI and total nutrition-related beliefs warrants further attention. This relationship is likely to be particularly important given the correlation between parent and child BMIz, albeit small, as well as the association seen between parent's total nutrition-related beliefs and eating behaviours previously discussed to be detrimental (e.g. reduced enjoyment of food, increased food fussiness and food responsiveness). Each individual nutrition-related belief was also related to eating behaviours in a similar detrimental manner. Of specific interest, parent's belief that 'healthy food doesn't taste good,' was positively related with child food fussiness and food responsiveness, and negatively with child enjoyment of food, which may reflect genetic tendencies and/or the transposing of beliefs about food and eating across generation. [3, 67, 399] As little attention has been given to understanding the constructs of parent's nutrition-related beliefs, or how these beliefs effect children's eating behaviours, interpretation of these findings is, however, limited. Examination of correlations between total nutrition-related beliefs and parent's feeding strategies, provides some insight, however, suggesting that perhaps parents with poorer nutrition related beliefs implement less responsive feeding strategies, as have been discussed to have a detrimental impact of children's eating behaviours. This theory would then suggest that to support parents implement responsive feeding strategies and promote eating behaviours consistent with maintaining a healthy bodyweight, attention should be given to shifting nutrition-related beliefs which are likely to reinforce changes in parent feeding strategies.

Of further interest, poorer total nutrition related beliefs were seen to correlate with lower total nutrition knowledge, which appears logical given that beliefs are understood to be functions of cognitive constructs. [348, 349, 380, 421] While the causality of this relationship between nutrition beliefs and knowledge cannot be determined, total nutrition knowledge was also seen to have a positive, desirable relationship with child enjoyment of food. Thus, improving parent's nutrition knowledge is likely to also support shifting parent's nutrition-related beliefs, which may further encourage adoption of more responsive feeding strategies and child enjoyment of food. [348, 349, 380, 421] In this regard, given that parent's grocery shopping skills were also seen to explain a reasonable amount of variance in child enjoyment of food and food fussiness, a more comprehensive focus on supporting parents to develop general food utilisation skills, as encompassing knowledge and beliefs along with food procurement abilities such as grocery shopping skills, may have beneficial impact on children's eating behaviours. [422] Interestingly, parent's cooking skills, the availability of fruit and vegetables within the home, sufficient money to buy food each week, and use of TV/electronic devices during meals did not explain a substantial amount of variance in eating behaviours as might be expected. It is interesting that use of TV and electronic devices during meals did not relate to food responsiveness as might be expected due to exposure to advertising.

4.1.4.6 Conclusion

This section provides a descriptive *picture* of the FFE's Australian children are exposed to during early childhood and extends on previous literature by examining the relationship between a wide range of FFE variables and children's eating behaviours. Although the findings of this section imply FFE's of Australian children are health promoting in many facets, these results should be interpreted with caution due to the use of repeat analysis which increased the risk of type 1 error. The results of this section, however, have been used to inform more robust analysis in the subsequent sections of this thesis (section 4.1.5).

Specifically, this section highlights several opportunities for future analysis, including investigation of mediator relationships between FFE variables, children's eating behaviours and child weight status, as consistent with the theoretical prospect of the behavioural susceptibility theory. In this regard, overt restriction appeared as the only continuous FFE variable that also showed correlation with child BMIz in this section. Given this, the following section explicitly explores the inter-relationship between overt restriction, child BMIz and related children's eating behaviours, as consistent with aim 3 of this thesis. While the behavioural susceptibility theory provides a solid theoretical framework from which to understand the intermediary role of eating behaviours in obesity status within the FFE, studies have not yet statistically confirmed this relationship.

Text and tables within section 4.1.5 are a reproduction of the manuscript published in the journal Obesity Science and Practice.

The citation is as follows:

Boswell, N., Byrne, R., & Davies, P. S. W. (2018). An examination of children's eating behaviours as mediators of parents' feeding strategies on early childhood obesity. Obesity Science and Practice, DOI:10.1002/osp4.320.

Available from: https://onlinelibrary.wiley.com/doi/full/10.1002/osp4.320

Contributor	Statement of contribution
Nikki Boswell	Conception and design of the study (60%) Analysis and interpretation of the data (60%) Drafting and critical review of manuscript (60%)
Rebecca Byrne	Conception and design of the project (20%) Analysis and interpretation of the data (20%) Drafting and critical review of manuscript (20%)
Peter Davies	Conception and design of the project (20%) Analysis and interpretation of the data (20%) Drafting and critical review of manuscript (20%)

4.1.5 Paper 3: An examination of children's eating behaviours as mediators of parents' feeding strategies on early childhood obesity

4.1.5.1 Introduction

The high prevalence and significant impact of obesity on physical, socio-emotional and economic health renders it an issue of major public health priority. [1, 423] The early childhood period is a crucial time to interject in the development of obesity as it is during this period that children develop socio-cultural and psychological associations with food and eating that can increase the risk of obesity. [399] Parents are considered key gatekeepers in the development of these associations, with parental feeding practices gaining much attention in the literature for their contributing role in shaping children's eating behaviours and obesity risk. [199, 249, 259]

Whilst there is evidence to specifically support a relationship between parent's use of restrictive feeding practices and increases in child weight, the evidence overall is not consistent. [249] A 2015 systematic review of cross-sectional and longitudinal studies involving children 4 – 12 years, for instance, reported restrictive feeding practices to be associated with increased child weight in 14 out of 21 studies, with findings predominantly from cross-sectional data. [249] Ogden et al., suggests that such inconsistencies may be due to different studies assessing some aspects of restrictive feeding which are beneficial to a child's eating and some which are detrimental. [260] This perspective seems relevant to the interpretation of this systematic review [249] since included studies used a range of measures to capture parent's use of restriction, which, unlike the more recently validated feeding practice and structure questionnaire (FPSQ), did not make distinctions between overt and covert restriction. [243, 244]

Overt restriction, as defined as 'controlling a child's food intake in a way that can be detected by the child,' is theorised to have a detrimental impact on children's eating by undermining a child's ability to self-regulate food intake through increased preoccupation with food [260, 309, 424], while covert restriction, as defined as 'controlling a child's food intake in a way that cannot be detected by the child,' is theorised to have a beneficial impact on child eating by providing structure and limits to appropriately guide a child. [260, 309, 424] While there is limited data examining the impact of these differing restrictive feeding practices on child weight, the evidence for impact on children's eating behaviours appears largely consistent with the theorised impact in cross-sectional, longitudinal and experimental studies. [243, 248, 259, 262] For instance, overt restriction has been seen to relate positively with the children's eating behaviour questionnaire (CEBQ) sub-scales food fussiness, food responsiveness, emotional eating (over- and under-eating) and desire to drink. [243] Since the CEBQ sub-scales food responsiveness, emotional over eating, and desire to drink are consistently associated with increased child weight, it is possible that overt restriction increases the risk of obesity. [7, 425] Although less evidence is available to reflect the relationship between covert restriction and children's eating behaviours [243], results of a recent cross-lag analysis of longitudinal data from the NOURISH RCT, showed that lower use of covert restriction at 2 years of age, increased food responsiveness at 3.7 years of age, as would also theoretically confer an increased obesity risk. [7, 259] These results were adjusted for child BMIz (at 14 months), however, they did not control for baseline eating behaviours which could alter interpretation.

Given this, further research is needed to examine the impact of both overt and covert restriction on child weight, as well as the inter-relationship of these variables with children's eating behaviours. In one of the few studies that has examined such an inter-relationship between restrictive feeding practices, child eating behaviours and child weight, Joyce and colleagues show that child disinhibited eating (a composite of food responsiveness and emotional eating sub-scales from the CEBQ) partially mediated the association between parent restriction and child BMI (4–8 years; n = 230). [265] A distinction was not made, however, between the type of restriction implemented in this study, which may have contributed to the small effect size and marginal significance reported. [265]

The present study hypothesised that overt and covert restriction would have distinct relationships with child BMIz and that children's eating behaviours would mediate the relationship between parent's use of overt and/or covert restriction, and child BMIz. The findings from this study will provide important insight into the unique role of overt and covert restriction in childhood obesity and behavioural intermediaries in these relationships and could provide opportunity for obesity prevention interventions.

4.1.5.2 Method

4.1.5.2.1 Recruitment and measures

Methods of recruitment and data collected have been detailed previously. [89] Briefly, between July and November 2016, Australian parents of children aged 2.0 – 5.0 years self-enrolled to complete an online survey. Recruitment was via advertising on the social media website Facebook®. No incentives were offered for participation. Participants were asked to use household measures (e.g. bathroom scales/ household tape measure) to report their weight and height, and that of their child, which were subsequently used to calculate body mass index (BMI) scores and categories (z-scores for children [BMIz]; according to the 2000 CDC growth charts for children; BMI categories as per Cole 2000 and 2007). [47, 48] As child height and weight were by parental report, data were screened for biologically implausible values (BIVs) as per Boswell et al. [89] Demographic variables recorded included child's age to the nearest half year, and gender, gender of the parent completing the questionnaire, family income reported as low, middle or high (less than $40,000, $40,000 - $100,000, or more than $100,000 per year, respectively), duration the response child was breastfed, and the region and Australian state of residency.

4.1.5.2.2 Children's eating behaviours

Of the 5 CEBQ sub-scales reported in this study (food responsiveness, satiety responsiveness, slowness in eating, food fussiness and enjoyment of food; as consistent with the scales measured by Webber, et, al. (2009) and Fildes, et, al., (2015)), previous analysis of these data has shown only food responsiveness (i.e. "Even if my child is full up s/he finds room to eat his/her favourite food") and satiety responsiveness (i.e. "My child gets full before his/her meal is finished,") to be significantly associated with child BMIz in multiple regression (B=.188, P=.02 and B= -.260, P=.01, respectively). [5, 67, 89] These CEBQ sub-scales were consequently analysed in this study. These CEBQ sub-scales showed acceptable internal reliability; Food Responsiveness (5 items; Cronbach α 0.921); satiety responsiveness (5 items; Cronbach α 0.800) and have previously been validated in an early childhood population (1 – 5 years) in Australia. [89, 179] Items were scored on a 5-point scale, with higher scores indicating higher values of each trait.

4.1.5.2.3 Parent's feeding practices

Sub-scales from the feeding practice and structure questionnaire (FPSQ-28) were used to measure parents' use of overt restriction (i.e. 'I intentionally keep some foods out of my child's reach') and covert restriction (i.e. 'How often do you avoid going with your child to cafes or restaurants which sell unhealthy foods?'). [243, 244] These sub-scales, as validated in a sample of Australian children 2 – 5 years, were scored as per the relevant literature. [244] Both included FPSQ-28 sub-scales produced a Cronbach α above 0.6 in the current study (Covert Restriction [4 items; Cronbach α 0.808], Overt Restriction [4 items; Cronbach α 0.604]).

4.1.5.2.4 Statistical method

The distribution of dependant variables was examined for multicollinearity and normality (skewness and kurtosis between 1 and -1). In order to determine the relation between FPSQ-28 sub-scales (overt and covert restriction) with CEBQ sub-scales (food responsiveness and satiety responsiveness), and child BMIz, correlation analysis was conducted. Where independent variables (overt and covert restriction) showed relation with child BMIz, additional relation with CEBQ sub-scales were examined to determine variables for further investigation as potential mediators

4.1.5.2.5 Exploration of mediators

To assess whether CEBQ sub-scales (food responsiveness and/or satiety responsiveness) mediated the relationship between restrictive feeding (overt and/or covert restriction) and child BMIz (controlling for previously identified covariates [89] and income), a bootstrapping procedure using the PROCESS macro for SPSS (Hayes, 2012) was conducted using 5000 resamples.

Bootstrapping procedure, as a nonparametric resampling procedure, is recommended as it assists in clarifying mediator relations and is recommended due to its robust nature and ability to determine mediator effect size. [426, 427] Specifically, PROCESS, a SPSS add-on, was used to perform bootstrapping with bias-corrected confidence estimates, as recommended. [426-428] The 95% confidence interval of the direct effects in this study were obtained with 5000 bootstrap resamples. [427] In using this bootstrapping method, if zero does not fall between the resulting confidence intervals, a significant mediation effect can be concluded. [427] PROCESS coefficients are reported as unstandardized, hence the confidence limits should not be interpreted as properly standardised. [427-429] All hypotheses assumed a 0.05 significance level and a two-sided alternative hypothesis. All analyses were carried out using SPSS v25 (SPSS Inc., Chicago, IL, USA). The SPSS add-on, PROCESS, was also used. [426] Covariates of child BMIz identified in previous analysis of these data (parent BMI, child age and being a boy), as well as income, will be controlled for.

4.1.5.3 Results

A sample of 977 Australian children, aged between 2.0 and 5.0 years, were retained for analysis in this study after the removal of BIVs (n=209). [89] As reported previously for this sample, excluded cases did not differ significantly based on parent BMI category, parent gender, single parent status, income group, or state or region of residency in one-way ANOVA analysis, however, were significantly younger (mean age 3.1 years, compared with 3.4 years, p=0.000) and were significantly more likely to be boys (58.0% in excluded case compared with 49.4% in retained sample, p=0.026). [89] Demographic variables of participants are in table 30.

Table 30: Demographic data (n = 977 [%])	
Gender	
Boy	483 (49.4)
Age	
2 years	108 (11)
2.5 years	161 (16.5)
3 years	153 (15.6)
3.5 years	164 (16.8)
4 years	173 (17.7)
4.5 years	128 (13.1)
5 years	90 (9.2)
Child BMI category[a]	
Underweight	219 (22.4)
Normal	586 (59.9)
Overweight	109 (11.1)
Obese	63 (6.5)
Child BMI z-score[b]	Mean -0.181 (SD 1.79)
Parent gender	
Men	52 (5.3)
Marital status	
Single	114 (11.7)
Parent BMI category[c]	
Underweight (<18.50kg/m^2)	13 (1.3)
Normal weight (18.50 - 24.99kg/m^2)	398 (40.7)
Overweight (≥25.00kg/m2)	254 (26.0)
Obese ≥30.00kg/m^2)	312 (32)
Breastfeeding history (collapsed from 5 categories)	
Less than 6 months	358 (36.6)
6 months or more	619 (63.4)
Income	
Low: less than AU$40,000	129 (13.2)

Middle: AU$40,000 - 100,000	407 (41.6)
High: more than AU$100,000	441 (45.2)
Australian state	
VIC	173 (17.7)
NSW	246 (25.2)
QLD	292 (30.0)
ACT	28 (2.9)
WA	122 (12.5)
TAS	29 (3.0)
NT	5 (0.5)
SA	82 (8.4)
Region type	
Capital city	255 (26.1)
Metro (population over 100,000)	301 (30.8)
Large rural (population 25,000 – 99,999)	188 (19.3)
Small rural (population 10,000 – 24,999)	128 (13.1)
Large remote (population 5,000 – 9,999)	41 (4.2)
Small remote (population less than 5,000)	64 (6.5)

N (%) reported for dichotomous variables
Mean (SD) reported for continuous
[a]Cut offs per Cole, TJ. (2000 and 2007)
[b]2000 CDC growth charts
[c]Cut offs per WHO classifications for adults (2000)

In correlation analysis, overt restriction was the only independent variable related to child BMIz. Overt restriction was also correlated with CEBQ sub-scale food responsiveness. For this reason, these variables were carried forward for additional analysis in the mediation model (table 31).

Table 31: Correlations matrix: CEBQ sub-scales, child BMIz and FPSQ sub-scales (n = 977)

	Child BMIz	Food responsiveness	Satiety responsiveness	Covert restriction	Overt restriction
Child BMIz	1	.096**	-.105**	.025	.063*
Food responsiveness		1	-.401**	.008	.260**
Satiety responsiveness			1	-.066*	.042
Covert restriction				1	.089**
Overt restriction					1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

4.1.5.3.1 Mediator analysis

In order to determine if the relation between overt restriction and child BMIz, controlling for covariates, was mediated by food responsiveness, mediation analysis with bootstrapping was performed. First, it was found that overt restriction was positively associated with child BMIz in the c-path (B =0.132, t (1, 975) =1.98, P = 0.048). Next it was found that overt restriction was positively associated with food responsiveness in the a-path (B = 0.230, t (5, 971) = 8.481, P=0.000). Finally, results indicated that the mediator, food responsiveness, was positively associated with child BMIz, in the b-path (B = 0.249, t (6,970) = 3.237, P = 0.001). As both the a-path and b-path were significant, mediation analyses were tested using the bootstrapping method with bias-corrected confidence estimates. [427, 428] Results of the mediation analysis confirmed the mediating role of food responsiveness in the relation between overt restriction and child BMI z-score (effect = .0575; CI = .0249 to .0990), controlling for covariates (parent BMI, child age, child gender [boy], and income). In addition, results indicated that the direct effect of overt restriction on child BMIz became non-significant (B = .057, t (6,970) =.848, P = 0.396) when controlling for food responsiveness, thus suggesting full mediation, explaining 5.75% of the relation (figure 10, table 32).

Table 32: Mediation analysis output (n=977)

		Food responsiveness[a] (M)				Child BMI z-score (Y)		
		Coeff.	SE	p		Coeff.	SE	p
Overt restriction[b] (X)					*C*	.132	.067	.04
	a	.230	.027	.00	*c'*	.057	.068	.39
M		-	-	-	*b*	.249	.077	.00
Constant		1.762	.19	.00		-.547	.478	.25
Covariates								
Parent BMI (kg/m^2)		-.007	.003	.04		.018	.008	.02
Boy		.060	.046	.19		-.583	.112	.00
Child age (years)		.071	.025	.00		-.191	.061	.00
Income		-.053	.034	.11		-.017	.081	.83
		R^2 = .083				R^2 =.052`		
		F (5, 971) = 17.72, P = 0.000				F (6,970) = 8.88, P=0.000		
		Effect		Bootstrap SE		BootLLCI		BootULCI
Indirect effect of X on Y		.0575		.018		.0249		.0990

Coeff. (Coefficient)
SE (Standard Error)
BootLLCI (Bootstrap Lower Level Confidence Interval)
BootULCI (Bootstrap Upper Level Confidence Interval)
a. CEBQ Sub scales (Wardle, et al. 2001)
b. FPSQ-28 Sub scales (Jansen, et al. 2016)

Figure 10: Mediation analysis: Overt restriction, food responsiveness, child BMIz

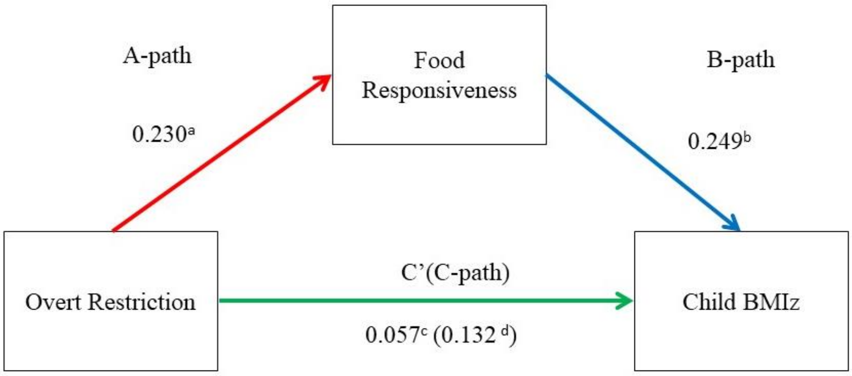


Figure 1. Indirect effect of overt restriction on Child BMI z-score through Food Responsiveness CI (.0249, .0990). The mediator could account for 5.75% of the effect

Note:[a] P=0.000, [b]P=0.001, [c]P=0.388, [d]P=0.048

4.1.5.4 Discussion

This study provides support for the differing roles of overt and covert restriction in childhood obesity and uniquely indicates the presence of a mediator relation between parent's use of overt restriction, child food responsiveness and child BMIz, controlling for parent BMI, child age, child gender and income. The results of this study add to the recommendation that parents should avoid use of overt restrictive feeding practices in young children, while the use of covert restriction may be more appropriate. [309, 424]

This recommendation makes sense from the perspective of a 'forbidden fruit effect' by suggesting that when children are aware of food restriction (e.g. overt restriction), they show increased preference for, and diminished self-regulatory behaviours towards food, which, may contribute to heightened food responsiveness. [246, 265, 297] From this perspective, it is likely that the impact of overt restriction on children's food responsiveness reflects activation of the hedonic appetite system and triggering of neurological 'liking' and 'wanting' the reference food. [75, 81] The use of overt restriction, thereby, may alter the reinforcing value of foods (liking) and weaken inhibitory neural control (wanting). [75, 81] This effect of overt restriction has been shown in experimental feeding studies wherein children's (3-5 years) eating behaviours towards a snack food was examined before, during, and after 5 weeks of overt restriction. [248] The results of this experiment demonstrated that during restriction to the target food, children significantly increased behavioural response to that food, relative to the control food. [248] This difference in response to the restricted food was not, however, observed before or after the restricted access period. [248]

In this regard, the results of this study suggest that the use of overt restriction is likely to be particularly problematic for children with tendencies towards food responsiveness, which is said to be 59% heritable. [113, 165] In support of this perspective, a study aiming to assess whether a child's (n=178, aged 9 – 10 years) Fat Mass and Obesity-Associated (FTO) gene moderated the relation between parents' restrictive feeding practices and child weight, showed parent restriction was positively associated with child BMIz only among children with high risk FTO alleles. [258] Although a distinction was not made between the type of restrictive feeding practices used by parents, the results may be relevant to the interpretation of this study due to the known association between FTO and obesogenic eating behaviours in children. [112, 151, 171] On this note, parents have also been reported to implement restrictive feeding practices in response to (maternal) perceptions of child appetite or concerns about child weight, which suggests a bi-directional relationship may exist. [249, 425, 430] Specifically, in investigating parent's (n =70 mother and father pairs) differential use of restrictive feeding practices between siblings (6 – 12 years) Payne et al., concluded that parents were more likely to use differential restrictive feeding practices when they had differential concerns for the weight status of their children (but not actual weight). [200] In this study, Payne et al., did not, however, make a distinction between the type of restriction implemented by parents which, as indicated, could alter the results seen. With this in mind, covert and overt restriction were positively correlated in the present study which may suggest that parents implement these restrictive feeding practices simultaneously.

While the mediator effect size between overt restriction, food responsiveness and child BMIz detected appears to be small (~6%), similar studies, particularly those that derive an effect size, are scarce, which limits comparison with previous research. A recent Australian study examining mediator relation between children's psychological problems, eating behaviours and child BMI using the SPSS add-on PROCESS, showed effect sizes in the realms of 5%. [431] That study conducted a secondary cross-sectional analysis of data from 194 children, 3.5-5 years of age (97% healthy weight), to show that food responsiveness (measured using the CEBQ) fully mediated the relation between child conduct problems (measured using the Strengths and Difficulties Questionnaire [SDQ]) and child BMIz, accounting for 5.33% of the variance in BMIz. [431] Similarly, Darling et al., examined mediation between restrictive/controlling feeding practices, food insecurity and child BMI percentile (n= 790, 7 - 17 years), reporting an effect size of 6.8% after controlling for familial income and child age. [432] The similar works of Joyce et al., who reported that children's disinhibited eating partially mediated the association between parent restriction and children's BMI (n=247, 4 – 8 years), have already been discussed. [265]

Neither Darling et al., or Joyce et al., made distinctions between the type of restriction implemented by parents', as highlighted across the literature and in the results of the present study to be of importance in obesity development. [252, 265, 432] Nor did they control for covariates of child weight. They did, however, make distinctions in terms of the context of parenting style, including additional factors such as general supportiveness, coerciveness and chaotic parenting, which are important to consider. [265] These findings highlight the complexity of understanding the context (e.g. genetic, socio-economic, socio-emotional, other parenting or home environment factors) through which restriction and child weight interact and highlights the need to consider these factors in addition to children's eating behaviours in future research. It appears warranted to direct attention towards better understanding of parent's motivations in implementing overt restriction (as distinguishing from covert restriction), and how these motivations differ in given contexts (genetic and environmental), particularly since the relation between restriction and food responsiveness is likely bi-directional. [38, 259]

While greater understanding of the context in which restrictive feeding influences child weight is needed, the intermediary role of food responsiveness in obesity development holds promise in obesity prevention initiatives. That is, targeting behavioural intermediaries, such as food responsiveness, is likely to provide a shorter-term measure of intervention effectiveness and overcome the time and resource burdens that accompany achievement of weight based outcomes. [259] Although it is acknowledged that food responsiveness has genetic components (as discussed), follow up of a recent intervention which used anticipatory guidance to increase parent's use of responsive feeding practices showed that intervention children, compared with the control group, had lower food responsiveness (2.3 vs 2.4, scored out of 5 on the CEBQ sub-scale, P =0.04). [113, 307] While this change was not seen to translate into lower BMI during this intervention timeframe, it does support the potential to alter eating behaviours via intervention, as obesity intermediaries. [307] On this note and irrespective of context, the wealth of literature supports that targeting parent's use of overt restriction is likely to diminish the influence of external food cues on the commencement of eating thus promoting healthier body weight.

Although this study is limited by its cross-sectional nature, it makes a unique contribution in statistically endorsing a mediator relation between overt restriction, food responsiveness and weight outcomes in early childhood in Australia. While the direction of this relation cannot be confirmed, the lack of association between covert restriction supports a distinctive effect of overt restriction on children's eating behaviours. Given this, measurements of both overt and covert restriction were a distinguishing feature of this study which provides insight to the influence of these feeding practices on children's eating behaviours and weight status. The large, geographically diverse sample used was also a noteworthy strength [89], as was use of well-established and previously validated tools to measure children's eating behaviours and parents' feeding practices. While less than desirable internal reliability scores for overt restriction is a limitation of this study, the Cronbach's alpha score achieved is comparable to those reported in a validation study of the FPSQ-28 in a sample of Australian children aged 2, 3.7, and 5 years, which ranged between 0.61 - 0.68 across these age categories. [244] These levels of internal reliability may be attributed to the few survey items included within this sub-scale, which can reduce Cronbach's alpha scores.

Given that anthropometric data used in this study were by parent report, steps were taken to ensure that included cases were biological plausible, as previously described. [89] This was a methodological strength of the analysis, since approximately 41% of large epidemiological studies do not address biological implausibility. [382] Additionally, a recent systematic review supports the use of self-reported BMI data specifically to screen children for overweight and obesity as a viable method, with good overall performance with moderate sensitivity and high specificity. [392] With this in mind, once cases of biologically implausible data were removed rates of overweight and obesity in this sample were comparable to national samples of 15.2% overweight and 5.5% obese (4 – 5 years of age), although rates of underweight appear to be over-represented compared with national data (22.4% v 7.55%, respectively). [10] Similar to what has been reported in other studies, anthropometric data deemed biologically implausible was higher in boys, although, contrary to other studies implausible data were higher in younger children. [390, 391] No differences in demographic characteristics were seen between children classified as underweight compared with other BMI categories. The use of bootstrapping to examine mediator relation is an additional strength of this study, given its robust nature and ability to determine effect size. [426, 427]

Despite these strengths, additional research, particularly longitudinal investigations with objectively measured BMI and observations of feeding and eating behaviours, are needed to better understand the relation between restrictive feeding practices, children's eating behaviours and child weight, particularly within different family contexts, genetic predispositions and in consideration of the motivations of parents in implementing overt feeding practices.

The results of this study indicate distinctly different roles of overt and covert restriction in child weight, with overt restriction associated with increased child BMIz. Food responsiveness additionally appears as an important behavioural intermediary in the relationship between overt restriction and child BMIz. Given this, it may be beneficial for future obesity prevention interventions to target parent's use of overt restriction as a means of reducing obesity risk. Further to this, food responsiveness, as an obesity intermediary, may be valuable as an interim measure of intervention effect.

The presence of a mediator relationship between food responsiveness, overt restriction, and child BMIz is an important finding in statistically confirming the propositions of the behavioural susceptibility theory, and in supporting understanding of variations in obesity risk based on neuro-biological predispositions towards eating behaviours. What this relationship does not capture, however, is that overt restriction does not occur in isolation from other FFE variables. By examining FFE variables collectively, as opposed to each variable individually, provides a more robust interpretation of the data and a more authentic view of environmental exposures as they interact with eating behaviours.

The relationship between FFE variables collectively, child weight status and eating behaviours has been examined in the following section as consistent with aim 4 of this thesis.

Text and tables within section 4.1.6 are a reproduction of the manuscript published in the journal BCM Obesity.

The citation is as follows:

Boswell, N., Byrne, R., & Davies, P. S. W. (2019). Family food environment factors associated with obesity outcomes in early childhood. BMC Obesity, DOI: 10.1186/s40608-019-0241-9.

Available from: https://bmcobes.biomedcentral.com/articles/10.1186/s40608-019-0241-9

Contributor	Statement of contribution
Nikki Boswell	Conception and design of the study (60%) Analysis and interpretation of the data (60%) Drafting and critical review of manuscript (60%)
Rebecca Byrne	Conception and design of the project (20%) Analysis and interpretation of the data (20%) Drafting and critical review of manuscript (20%)
Peter Davies	Conception and design of the project (20%) Analysis and interpretation of the data (20%) Drafting and critical review of manuscript (20%)

4.1.6 Paper 4: Family food environment factors associated with obesity outcomes in early childhood

4.1.6.1 Background

Childhood obesity is a multifactorial condition which involves interaction between genetics, environments and behavioural responses. [55, 294] A key example of this is the interaction between children's eating behaviour and the family environment in the development of childhood overweight and obesity. [5, 7] Eating behaviours such as food responsiveness and enjoyment of food, referred to as food approach eating behaviours, are positively associated with obesity development, while food avoidance eating behaviours, such as satiety responsiveness, food fussiness and slowness in eating, have been seen to be negatively associated with obesity development. [5, 7] Given this, much attention has focused on initiatives which aim to alter 'obesogenic' behaviours and obesity development via environmental modifications. [65, 250] For such interventions to be effective, however, a thorough understanding of environmental contexts and their influence on obesity and behavioural intermediaries is necessary.

Whilst environmental influences are considered to operate at multiple levels, as conceptualised through the socio-ecological model, for children, the family food environment (FFE) has been seen to explain the greatest variance in obesity, compared with school and neighbourhood level influences, and is a prime context in which children's eating behaviours emerge. [12, 52, 191] As the 'first ecological niche of children,' it is within the confines of the FFE that parents impose socio-cultural values and practices around food and eating occasions (interpersonal influences of the socio-ecological model), as regulated by the structural boundaries and resource limitations of the home (micro-environment influences of the socio-ecological model). For instance, interpersonal influences such as parental use of controlling feeding practices have been associated with increased body weight in children as well as tendencies towards obesogenic eating behaviours. [251, 252, 296, 297] Similarly, micro-environment influences such use of television (TV) during meals and availability of fruit and vegetables within the home, have been associated with obesogenic eating behaviours and increased body weight. [67, 277, 292, 303]

While the literature to date has highlighted the potential importance of numerous FFE variables (e.g. parental feeding strategies, frequency of family meals, the use of TV and electronic devices during meals, cooking and home resources, parent's food and nutrition related beliefs, parent's cooking and shopping skills, parent's nutrition knowledge) in the development of obesity and obesogenic eating behaviours, the collective influence of these variables, has not been considered. [207, 214, 222, 250, 277] Considering FFE variables independently limits understanding of the collective impact of variables, as a more authentic reflection of the environmental context in which obesity and obesogenic eating behaviours develop. For instance, while non-responsive feeding strategies (e.g. parental use of pressure, bribes, coercion and control) have been seen to be associated with childhood obesity and 'obesogenic' eating behaviours, research has not examined the occurrence of other FFE variables, such as use of TV during meals, the frequency of family meals, availability of fruit and vegetables or parent's nutrition knowledge, which may partner with non-responsive feeding strategies to have an impact on obesity development. [5, 7, 201, 239, 246, 250, 252, 297] Additionally, consideration has not been given to exploring differences in collections of FFE variables based on psycho-social factors such as income, parent's marital status, parent's depression, anxiety and stress, region of residence, or parent's body mass index (BMI), which are likely to have a significant impact on the FFE and consequently may contribute to explanations of inequitable distribution of obesity risk within the population.

Given this, this study aims to use factor analysis to derive composites of FFE variables, to provide a more authentic reflection of FFE exposure during early childhood in Australia. Highlighting FFE variables that appear to group together in this way offers a novel perspective from which to further examine the development of obesity and obesogenic eating behaviours. Additionally, since psycho-social factors such as income, parent's marital status, parent's depression, anxiety and stress, and parent's BMI, are likely to have a distinctive impact on the FFE constructed, relationships between these variables and FFE factors will be examined.

4.1.6.2 Method

Between July and November, 2016, Australian parents of children aged 2.0 – 5.0 years self-enrolled to complete an online, cross sectional survey. Participants self-selected to enroll in the survey through advertising on the social media website Facebook®. Children were excluded from this study if they were reported to have a medical condition likely to affect their growth, development or metabolism. In the instance that a parent had more than one child within the target group, parents were asked to refer to the child whose birthday occurred next. No incentives were offered for participation in this survey.

Participants were asked to use household measures (e.g. bathroom scales/ household tape measure) to report their weight and height, and that of their child, which were subsequently used to calculate BMI categories (according to the 2000 CDC growth charts for children; BMI categories as per Cole 2000 and 2007). [47, 48] As child height and weight were by parental report it was deemed necessary to screen the data for biologically implausible values. The process used to screen these data for biologically implausible values has previously been reported. [89]

Children's eating behaviours were measured using sub-scales of the children's eating behaviour questionnaire (CEBQ; enjoyment of food, food responsiveness, satiety responsiveness, food fussiness and slowness in eating). Internal reliability of these scales for this sample has previously been reported (see Boswell, et al., 2018) and ranged from Cronbach α 0.921 - 0.677. [89] The CEBQ has been well validated across the literature including in Australian samples of young children.

Demographic variables recorded included child's age, recorded to the nearest half year, the gender of the parent that completed the questionnaire, the child's gender, family income reported as low (less than AU$40,000), middle (AU$40,000 – AU$100,000) or high (more than AU$100,000), the duration the response child was breastfed, and Australian state and region of residency (based on rural, remote and metropolitan areas (RRMA) classification). [372] Parent's depression, anxiety and stress levels, as an important covariate of childhood obesity identified in these data previously (see Boswell, et al, 2018) were measured using the depression, anxiety and stress scale [DASS-21]. [89, 373] Variables conceptualized within the FFE, as aligning with interpersonal and micro-environment levels of the socio-ecological model, were measured as per the scales described below and screened for internal reliability.

Parent's feeding practices and structure

The 8 FPSQ-28 sub-scales, as validated in a sample of Australian children 2 – 5 years, were scored as per the relevant literature. [244] All FPSQ-28 sub-scales produced a Cronbach α above 0.6 (reward for behaviour [4 items; Cronbach α 0.820], reward for eating [4 items; Cronbach α 0.672], persuasive feeding [6 item; Cronbach α 0.803], covert restriction [4 items; Cronbach α 0.808], overt restriction [4 items; Cronbach α 0.605], structured meal setting [3 items; Cronbach α 0.865], structured meal timing [3 items; Cronbach α 0.670], and family meal (single item).

The frequency of family meals

The frequency of family meals was measured using three items, reflecting breakfast, lunch and dinner, to create a total frequency of family meal score (out of 21).

General nutrition knowledge

A general nutrition knowledge score (out of 13) was created based on a general knowledge questionnaire guided by the works and recommendations of Parmenter, et al., (1999), and a similarly adapted version validated for use with Australian adults. [374, 378]

Nutrition related beliefs

Four nutrition related belief items were measured (‘Eating healthy is expensive,’ ‘It takes too long to prepare a healthy meal,’ ‘Healthy food doesn’t taste good,’ Nutrition is important to your family’). Items were devised based on key barriers to healthy eating qualitatively themed from a sample of Australian adults and phrased as a belief by assigning attributes to identified barriers towards healthy eating. [379, 380] Each item was scored individually as a categorical variable. A higher score on this scale reflects poorer nutrition related beliefs.

Parental depression, anxiety and stress

Parental depression, anxiety and stress was measured using the DASS-21, depression, anxiety and stress scale. [373] The DASS-21 is a 21 item self-report questionnaire designed to measure the severity of a range of symptoms common to depression, anxiety and stress over the previous week. [403] Data from this study showed high internal reliability for each scale; stress [7 items; Cronbach α 0.837] anxiety [7 item; Cronbach α 0.742] depression [7 items; Cronbach α 0.886]. Each DASS scale was examined for normality (skewness and kurtosis between 1 and -1). Depression and anxiety scales were deemed skewed so transformed accordingly, however, the stress scale was normally distributed.

Home resources and parent’s personal skills

Parent’s cooking and grocery shopping skills, along with the availability of fruit and vegetables within the home, cooking facilities, food storage facilities, and the use of TV/electronic devices during meals (3 separate items: family use, child use, and adult use), were reported as categorical variables on Likert or on nominal scales.

Ethics approval

Ethical approval for this research project has been granted through The University of Queensland (approval number 2016000860).

Statistical method

The distribution of predictive variables was examined for multicollinearity and normality (skewness and kurtosis between 1 and -1). Factor analysis, with Kaiser-Mayer-Olkin measure and Bartlett test of sphericity was run to create composites of FFE variables, with orthogonal rotation (Varimax) performed to determine how strongly a variable contributed to a FFE factor, based on eigenvalues >1. Intra-correlation between variables was assessed using Kaiser-Mayer-Olkin measure, with values >0.5 considered to indicate good intra-correlation. [433, 434] Variables with value <0.5 were removed and analysis rerun, as recommended by Fields, 2005. [433] Items were loaded on a factor if they had a positive or negative correlation >0.25 with that factor and named descriptively. [435, 436]

To examine whether BMI categorization showed linear associations with derived FFE factors, a one-way between-groups multivariate analysis of variance (MANOVA) was performed. Pillai's Trace was examined for significance, homogeneity of variance assumption examined with Levene's F tests and one-way ANOVA's conducted with post-hoc contrasts (LSD) performed. [7]

Stepwise regression was conducted to examine associations between FFE factors and CEBQ scores, adjusting for known covariates in step 1 (parent BMI, child gender, breastfeeding history (binary coded less than 6 months vs more than 6 months), child sleep duration, income (binary coded low-income vs other), region of residency (binary coded Capital City vs other), parent's depression, anxiety and stress). Coefficients, confidence intervals and mean scores were inspected to check the direction and pattern of the association. All hypotheses will assume a 0.05 significance level and a two-sided alternative hypothesis. All analyses were carried out using SPSS v24 (SPSS Inc., Chicago, IL, USA).

4.1.6.3 Results

A sample of 977 participants was obtained from an initial sample of 1184 parents of Australian children, aged between 2.0 and 5.0 years who completed the survey, once cases of biologically implausible values and outliers were removed (as reported in Boswell, et al., 2018). [89] On comparison with national data, children categorised as underweight appeared to be overrepresented (7.6% vs 22.4%, respectively). [10] Given the focus of this study on the collective contribution of FFE variables to overweight and obesity in children, in comparison to normal weight children, it was decided to exclude underweight children from further analysis leaving a sample of n=758. [10] In further support for this approach, a recent systematic review deemed the use of self-reported BMI data as acceptable specifically to screen children for overweight and obesity, with good overall performance with moderate sensitivity and high specificity, but the validity for underweight children is not clear. [392] Excluded cases did not differ significantly based on parent BMI category, parent gender, single parent status, income group, or state or region of residency in one-way ANOVA analysis, however, were significantly younger (mean age 3.1 years, compared with 3.4 years, p=0.000) and a higher proportion were boys (58.0% in excluded case compared with 49.4% in retained sample, p=0.026) (table 33).

Table 33: Demographic data

	Total sample n = 977 (%)	Normal weight, overweight and obese only n=758 (%)
Child Gender - Boy	483 (49.4)	376 (49.7)
Age		
2 years	108 (11.0)	83 (11.0)
2.5 years	161 (16.5)	128 (16.9)
3 years	153 (15.6)	126 (16.6)
3.5 years	164 (16.8)	120 (15.9)
4 years	173 (17.7)	136 (18)
4.5 years	128 (13.1)	94 (12.4)
5 years	90 (9.2)	70 (9.2)
Child BMI category[a]		
Underweight	219 (22.4)	excluded
Normal weight	586 (59.9)	586 (77.4)
Overweight	109 (11.1)	109 (14.4)
Obese	63 (6.5)	63 (8.2)
Child BMI z-score[b] (Mean)	-0.18 (SD 1.79)	0.52 (SD 1.07)
Parent gender - male	52 (5.3)	42 (5.5)
Parent BMI category[c]		
Underweight (<18.50kg/m^2)	13 (1.3)	12 (1.6)
Normal weight (18.50 - 24.99kg/m^2)	398 (40.7)	305 (40.3)
Overweight (≥25.00kg/m2)	254 (26.0)	196 (25.9)
Obese ≥30.00kg/m^2)	312 (32.0)	244 (32.2)
Breastfeeding history		
Less than 6 months	358 (36.6)	276 (36.5)

6 months or more	619 (63.4)	481 (63.5)
Income		
Low: less than AU$40,000	129 (13.2)	103 (13.6)
Middle: AU$40,000 - 100,000	407 (41.6)	320 (42.3)
High: more than AU$100,000	441 (45.2)	334 (44.1)
Australian state		
Victoria	173 (17.7)	133 (17.6)
New South Wales	246 (25.2)	189 (25)
Queensland	292 (30.0)	230 (30.4)
Australian Capital Territory	28 (2.9)	21 (2.8)
Western Australian	122 (12.5)	93 (12.3)
Tasmania	29 (3.0)	23 (3.0)
Northern Territory	5 (0.5)	4 (0.5)
South Australia	82 (8.4)	64 (8.5)
Region type		
Capital city	255 (26.1)	201 (26.6)
Metro (population over 100,000)	301 (30.8)	235 (31.0)
Large rural (population 25,000 – 99,999)	188 (19.3)	145 (19.2)
Small rural (population 10,000 – 24,999)	128 (13.1)	93 (12.3)
Large remote (population 5,000 – 9,999)	41 (4.2)	32 (4.2)
Small remote (population less than 5,000)	64 (6.5)	51 (6.7)

N (%) reported for dichotomous variables; Mean (SD) reported for continuous

[a]Cut offs per Cole, TJ. (2000 and 2007); [b]2000 CDC growth charts; [c]Cut offs per WHO classifications for adults (2000)

Data presented in this table has previously been published in Boswell, et al., (2018)[89]

Family food environment factors

Eight factors reflecting FFE were extracted from the factor analysis, explaining between 9.37% and 4.89% of the variance in FFE (cumulative variance explained 56.74%). A Kaiser-Mayer-Olkin measure of 0.704 was achieved with significance in Bartlett's test of sphericity (p=0.000), indicating acceptable correlation (table 34). [433, 434]

Table 34: Varimax- rotated family food environment variables loading on factors extracted[a] (n=758)								
	1 Negative feeding strategies[c]	2 Negative nutrition related beliefs[c]	3 High resources[c]	4 High skill[c]	5 Health focused restriction[c]	6 Family meals[c]	7 TV and devices[c]	8 Parent's nutrition knowledge[c]
Belief: Healthy eating is expensive		**.712**						
Belief: It takes too long to prepare healthy food		**.696**						
Belief: Healthy food doesn't taste good		**.583**						
Belief: Healthy eating is important					**.650**			
Suitable cooking facilities			**.878**					
Suitable food storage			**.870**					
Sufficient money to buy food each week		**-.562**	**.397**					
Parent's shopping skills				**.754**				
Parent's cooking skills				**.836**				
Single family meal[b]						**.683**		
Food as a reward for eating[b]	**.817**							
Food as a reward for behaviour[b]	**.698**							
Parent use of persuasive feeding[b]	**.717**							**-.272**
Parent use of covert restriction[b]					**.723**			
Parent use of overt restriction[b]	**.437**				**.464**			
Structured meal setting[b]	**.359**					**.421**		
Structured meal timing[b]					**.302**	**-.353**	**-.332**	
Frequency of family meals per week						**.630**		
Parent total nutrition knowledge								**.833**
Family use of TV during meals (yes/sometimes)						**-.303**	**.362**	**-.416**
Child use of devices during meals (yes/sometimes)							**.682**	
Adult use of devices during meals (yes/sometimes)							**.677**	
Availability of fruit and vegetables (Sometimes/never)		**.383**		**-.260**			**.292**	

Extraction method: Principal Component Analysis.

Rotation method: Varimax with Kaiser Normalization.

a. In interest of table readability, family food environment variables loading < 0.25 and <-0.25 are not shown

b. FPSQ-28 Sub Scales (Jansen, et al. 2016)

c. Loadings ≥0.25 in bold to aid labelling of family food environment factors

Variance explained by each factor are as follows:

Factor 1 Negative feeding strategies: 9.37%

Factor 2 Negative nutrition related beliefs: 8.82%

Factor 3 High resources: 7.89%

Factor 4 High skill: 6.67%

Factor 5 Health focused restriction: 6.59%

Factor 6 Family meals: 6.45%

Factor 7 TV and devices: 6.02%

Factor 8 Parent’s nutrition knowledge: 4.89%

Family food environments & child BMI category

A statistically significant difference existed between child BMI categories (normal weight, overweight and obese) for four FFE factors in the MANOVA, with Pillais' Trace= 0.046, $F(16, 1498) = 2.22$, $p= 0.004$. The multivariate effect size was estimated at 0.023, which implies that 2.3% of the variance in the dependent variables was accounted for by BMI categories. Based on a series of Levene's F tests, the homogeneity of variance assumption was considered satisfied for all factors except Factor 2, however, as of the largest standard deviations were not more than four times the size of the corresponding smallest standard deviation, it was considered, in accordance with Howell, (2007), that ANOVA would be robust. [411]

ANOVA's for Factor 1 'Negative feeding strategies', Factor 2 'Negative nutrition related beliefs', Factor 7 'Use of TV and devices', and Factor 8 'Parent's nutrition knowledge' were statistically significant ($p=0.046$, $p=0.004$, $p=0.049$ and $p=0.032$, respectively), with effect sizes (partial n^2) ranging from 0.008 to 0.015 (table 3). In post-hoc analyses (Fisher's LSD) examining individual mean difference in factor scores across BMI categories, statistically significant differences were seen in Factor 1 'Negative feeding strategies' between normal weight and obese ($p=0.017$) and overweight and obese ($p=0.026$), such that obese children scored highest on this factor. Factor 2 'Negative nutrition related beliefs' differed significantly between normal weight and overweight ($p=0.003$) and between normal weight and obese ($p=0.047$), such that normal weight scored lower on this factor. Factor 7 'Use of TV and devices', differed significantly between normal weight and obese ($p=0.032$) such that normal weight scored higher on this factor. Factor 8 'Parent's nutrition knowledge' differed significantly between normal weight and obese ($p=0.012$) and between overweight and obese ($p=0.017$), such that obese scored lower on this factor (table 35).

Table 35: Family food environment factor differences by child BMI category (MANOVA)					
Family food environment factors*	**Normal weight (n=586) Means (SD)**	**Overweight (n=109) Means (SD)**	**Obese (n=62) Means (SD)**	**Sig. (p value)**	**Partial n2**
Factor 1: Negative feeding strategies[1]	-0.021 (1.0)	-0.056 (0.95)	0.296 (0.98)	**0.046**	0.008
Factor 2: Negative nutrition related beliefs[2]	-0.065 (1.0)	0.239 (0.98)	0.196 (1.13)	**0.004**	0.015
Factor 3: High resources[3]	-0.009 (1.0)	0.132 (0.87)	-0.136 (1.15)	0.209	0.004
Factor 4: High skill[4]	0.011 (0.99)	-0.072 (1.05)	0.033 (1.03)	0.658	0.001
Factor 5: Health focused Restriction[5]	-0.000 (1.02)	-0.048 (0.97)	0.088 (0.87)	0.690	0.001
Factor 6: Family meals[6]	-0.000 (1.00)	0.027 (0.97)	-0.041 (1.01)	0.901	0.000
Factor 7: TV and devices[7]	0.045 (1.01)	-0.106 (1.03)	-0.238 (0.83)	**0.049**	0.008
Factor 8: Parent's nutrition knowledge[8]	0.021 (0.98)	0.065 (1.05)	-0.311 (1.02)	**0.032**	0.009

*Factor characteristics:

1: Food as a reward for eating, food as a reward for behaviour, parent use of persuasive feeding, parent use of overt restriction, structured meal setting,

2: Belief: Healthy eating is expensive, Belief: It takes too long to prepare healthy food, Belief: Healthy food doesn't taste good, availability of fruit and vegetables, sufficient money to buy food each week (negatively loaded)

3: Suitable cooking facilities, suitable food storage, sufficient money to buy food each week

4: Parent's shopping skills, parent's cooking skills, availability of fruit and vegetables (negatively loaded)

5: Belief: Healthy eating is important, parent use of covert restriction, parent use of overt restriction, structured meal timing,

6: Single family meal, structured meal setting, structured meal timing (negatively loaded), frequency of family meals per week, family use of TV/devices during meals (negatively loaded)

7: Structured meal timing (negatively loaded), family use of TV/devices during meals, child use of TV/devices during meals, adult use of TV/devices during meals, availability of fruit and vegetables

8: Parent use of persuasive feeding (negatively loaded), parent total nutrition knowledge, family use of TV/devices during meals (negatively loaded)

Relation between FFE factors and children's eating behaviours, controlling for covariates

After controlling for covariates in step 1, 'Negative feeding strategies' was positively associated with food fussiness (β=0.201, p=0.001), and food responsiveness (β=0.305, p= 0.000), 'Negative nutrition related beliefs' was positively associated with food responsiveness (β=0.117, p=0.018), and 'Parent's nutrition knowledge' was negatively associated with slowness in eating (β=-0.108, p=0.031). No CEBQ sub-scales were significantly associated with 'TV and devices' (table 36).

Table 36: Variables predictive of family food environment factors, controlling for covariates (excluding UW)								
	Factor 1: Negative feeding strategies		**Factor 2: Negative nutrition related beliefs**		**Factor 7: TV and devices**		**Factor 8: Parent's nutrition knowledge**	
***Step 1* - Covariates**	**B (SE)**	**B (P Value)**	**B (SE)**	**B (P Value)**	**B (SE)**	**B (P Value)**	**B (SE)**	**B (P Value)**
Parent BMI	-0.793 (0.321)	-0.110 (0.014)	1.658 (0.318)	0.226 (0.000)				
Child sex (male)			0.179 (0.087)	0.087 (0.040)				
Breastfeeding less than 6 months			0.182 (0.090)	0.087 (0.044)			-0.237 (0.099)	-0.111 (0.017)
Child sleep duration								
Low income			0.400 (0.119)	0.147 (0.001)			-0.380 (0.129)	-0.138 (0.003)
Parent anxiety								
Parent depression								
Parent stress							0.350 (0.141)	0.155 (0.014)
Capital city residency					0.236 (0.109)	0.099 (0.031)	0.270 (0.112)	0.114 (0.015)
***Step 2* - Children's eating behaviour questionnaire sub-scales**								
Enjoyment of food								
Food fussiness	0.214 (0.065)	0.201 (0.001)						
Food responsiveness	0.410 (0.068)	0.305 (0.000)	0.160 (0.067)	0.117 (0.018)				
Satiety responsiveness								
Slowness in eating	0.237 (0.069)	0.161 (0.001)					-0.164 (0.076)	-0.108 (0.031)

4.1.6.4 Discussion

The current study greatly extends on previous research by deriving factors of FFE variables to more authentically examine how a broad scope of interpersonal and microenvironment influences (aligned with the socio-ecological model) combine and relate to the development of obesity and obesogenic eating behaviours during early childhood. Only two previous studies have been identified which similarly attempted to derive factors or clusters of FFE variable to examine the combine effect of variables on obesity development, however, these studies limited their focus to dining times, physical activity/play time, and screen time, which does not capture the range of variables conceptualised within the FFE as described in this paper. [437, 438]

This study specifically found four of the eight FFE factors derived to be associated with child BMI category. Scores for Factor 1 'Negative feeding strategies,' and Factor 2 'Negative nutrition related beliefs,' were seen to increase across increasing BMI category (normal weight, overweight and obese), while scores for Factor 7 'Use of TV and devices', and Factor 8 'Parent's nutrition knowledge', were seen to decrease. The relationship between these factors with BMI category were in the expected direction (as will be discussed) in all cases except for Factor 7 'Use of TV and devices', which, in accordance with the literature, could be expected to relate to an increased weight status due to the impact TV use is reported to have on satiety signals and food cue responsivity (through exposure to food advertising). [12, 209] Additionally, the limited use of structured meal timing, as also loaded on this factor, could be considered a detrimental aspect of children's nutrition environments that theoretically contributes negatively to a child's BMI. [12, 209, 244] That is, lack of structure around meal times fails to establish the routine and predictability that underpins responsive feeding practices, as associated across the literature with detrimental eating behaviours and obesity development. [253] This unexpected direction of the relationship between Factor 7 'Use of TV and devices' may in part be explained by the positive association between this factor and residing in a capital city, which is generally associated with more positive health outcomes and may be related to a variety of other 'protective' factors. Irrespective of this, this relationship requires further investigation, particularly in light of changing uses of technology whereby exposure to food advertising may be less pertinent.

Likewise, while it was expected that higher nutrition knowledge of parents (Factor 8) would be associated favourably with child BMI, as seen in this study, the literature reflecting this appears inconsistent. [223, 237, 271-273] This inconsistency across the literature in part may be attributed to the difficulty in measuring nutrition knowledge, however, it may also be due to nutrition knowledge acting as a proxy for more 'advantaged' life circumstances, as supported by the findings of this study which shown Factor 8 'Parent's nutrition knowledge' to be associated with residing in a capital city, breastfeeding for more than 6 months and not identifying as of low income. The effect of such 'advantaged' life circumstances may further be reflected in the positive association between 'Parent's nutrition knowledge' (Factor 8) and slowness in eating, as a food avoidance eating behaviour associated with a reduced obesity risk, although, in previous analysis of these data slowness in eating was not significantly associated with child BMI. [5, 7, 89] Alternatively, given that use of persuasive feeding strategies, as a 'non-responsive' feeding practice associated with childhood obesity, and family use of TV during meals, as discussed to be detrimental, also loaded negatively onto Factor 8, the inconsistencies previously seen in the literature between nutrition knowledge and weight status, could be due to failing to consider other aspects of the FFE that work synergistically with nutrition knowledge and support the translation of knowledge into health behaviours. [253]

Given the strength of the relationship between non-responsive feeding practices and childhood obesity, as seen in a systematic review of 31 studies, 20 of which specifically involved children during early childhood, the relationship between Factor 1 'Negative feeding strategies' and child BMI category in this study is generally not surprising. [253] What is interesting in relation to Factor 1 'Negative feeding strategies,' however, is that the feeding practice *structured meal setting*, as a responsive feeding practice hypothesised to allow children to eat in a setting in which they can attend to their internal cues of hunger and satiety, also loaded onto this factor. This somewhat contradictory finding in this study, again highlights the importance of considering FFE variables as composites, reflecting an authentic environmental exposure. In this instance, while the hypothesise of a structured meal setting allowing a child to attend to their hunger and satiety cues holds much merit, the findings of this study suggest that when combined with other non-responsive feeding practices such as overt restriction and food as a reward, the overall impact on a child's weight and eating behaviours (namely food fussiness and food responsiveness; table 4) is negative. This could be due to the overall context and family climate in which such structure around meal settings is imposed, as consistent with the idea of authoritarian parenting (high control, rigidness, low responsiveness) which has similarly been seen to be associated with childhood obesity as well as the use of a range of non-responsive feeding practices. [270, 439]

Of further interest, Factor 1 ‘Negative feeding strategies’ was seen to be negatively associated with parent BMI, although no other psycho-social variables. This negative association with parent’s BMI, in the absence of other psycho-social variables which would contribute to a high risk factors for childhood obesity, is likely to be particularly important in highlighting the increased risk of obesity development imposed on children by parents who implement non-responsive feeding strategies irrespective of psycho-social risk. [247] Tripicchio, et al., (2014), similarly showed this, by demonstrating that after controlling for shared environment and genetics, restrictive feeding practices were associated with child weight status. [202] The findings of this study are further consistent with the literature which has shown non-responsive feeding strategies to relate to eating behaviours such as food responsiveness and food fussiness. [252, 296, 297]

While the intention of parents in implementing such non-responsive feeding practices are likely well intended, given the bi-directional relationship between feeding practices and children’s eating behaviours, particularly food responsiveness as shown by Jansen, et al., (2018), and associated with Factor 1 (Negative feeding strategies), it is plausible that parents implement such non-responsive feeding strategies in an attempt to modulate eating behaviours and/or control child weight. [259] Additionally, given that Factor 1 was also associated with food fussiness, it is possible that a similar bi-directional relationship food fussiness and strategies intended to overcome such difficult meal time behaviours occurs. Jansen, et al., (2017) and Harris, et al., (2016), have specifically shown the presence of a bi-directional relationship with non-responsive feeding practices and fussy food behaviour in young children. [201, 440] Given this likely misdirection of parent’s good intentions in feeding their child, intervention strategies which focus on providing support for parents to understand and interpret their child’s individual tendencies/innate eating behaviours, as well as implement the appropriate responsive feeding strategies, are likely to be of importance in reducing obesity development and/or in modifying obesogenic eating behaviours.

On this note, in addition to examining the cumulative impact of FFE variables on children’s eating behaviours and obesity development, this study provides insight into the relationship between psycho-social variables and FFE factors which may contribute to understanding of inequitable obesity risk within the population and directly extends on our previous research which explored the relationship between children's eating behaviour with psycho-social variables, as were hypothesised to impact upon children's eating behaviours and obesity development through neuro-biological pathways. [89] This extended perspective on the contribution of FFE variables on the development of obesity, and the examination of psycho-social variables associated with these factors, is likely to be of benefit in planning obesity prevention interventions which are more appropriately targeted, in consideration of authentic FFE exposure. For instance, obesity prevention initiatives focusing on constructs aligning with the cumulative use of 'Negative feeding strategies' may have general suitability to early childhood populations since no demographic variables were associated with this factor. In more specifically targeting lower socio-economic populations, however, children of parents with obesity, and/or boys in particular, framing interventions towards variables cumulatively associated with the factor 'Negative nutrition beliefs,' such as availability of fruits and vegetables within the home and parental skills to prepare quick, healthy, tasty and affordable meals, may be more appropriate. Longitudinal studies are additionally needed, however, to better inform such future directions particularly given that during the early childhood period obesity is still emerging and as such alternative FFE factors could have differing longitudinal impacts on obesity development. Factor 3 'High resources' and Factor 4 'High skills,' for instance, may have an obesity protective effect longitudinally that was not seen cross-sectionally in this study.

Strengths and weaknesses

This study captures a broad scope of variables conceptualised within the FFE and uniquely considers the collective influence of these variables on childhood obesity development. Whilst this study is limited in its exclusion of physical activity measures, the inclusion of children's eating behaviours is a strength given the significant relationship between CEBQ sub-scales and obesity development, as is the inclusion of parent's feeding practices and strategies, as a pivotal socio-cultural influence widely examined for its role in the development of obesity and eating behaviours. [2, 5, 222, 294, 296, 298, 437, 438] On this note, the use of the CEBQ, the FPSQ-28, as well as the DASS-21, adds strength to this study as these measures have been well validated across the literature. [179, 243, 244, 373] Caution in interpretation of these results should, however, still be taken due to several survey items being adapted specifically for this study which may compromise validity.

In this regard, the inclusion, and consequently significance of, parent's nutrition-related beliefs is a unique and important aspect of this study. Little attention has been given in the literature to understanding the role of parent's specific beliefs and attitudes towards food and nutrition, which, based on the findings of this study, play a significant role in the development of obesity and obesogenic eating behaviours. Whilst the effect of these beliefs on child weight was seen cumulatively and alongside other FFE variables in this study, the specificity of the beliefs measured is highly informative in terms of understanding current facilitators of nutrition-related behaviours as well as opportunities to consequently support behaviour change. Further attention in the literature should be given to exploring this role of parent's nutrition-related beliefs on child weight and eating behaviours through use of additionally validated measures.

While the inclusion of a broad range of covariates in this study allows for a thorough picture of psycho-social influences on FFEs of children during early childhood in Australia, it is recognised that this may increase the risk of type 1 errors. While no adjustments were made for this, it can be seen in table 36 that the many of p-values are quite low and as such the interpretation of the majority of results would not differ with adjustment. Despite being cross-sectional in nature, this study is strengthened by the large sample of participants representing all states and territories in Australia. Single parents were represented at a rate comparable to the 15% reported nationally, and distribution of participants in the high and middle income groups were represented similarly, although low income families were underrepresented. [235] This under-representation of low income families is likely to be a limitation of this study which impacts the generalisability and application of these results, particularly in obesity prevention initiatives. Although anthropometric data in this study were self-reported, steps were taken to ensure the biological plausibility of included cases, as is considered a quality feature given that approximately 41% of large epidemiological studies do not address biological implausibility. [382] Similar to what has been reported in other studies, anthropometric data deemed biologically implausible values were higher in boys, although, contrary to other studies implausible data were higher in younger children. [390, 391] No differences in demographic characteristics were between children classified as underweight compared with other BMI categories.

On this note, although underweight children were excluded from analysis in this study, the decision to do so is well justified. Firstly, the overrepresentation of underweight children in the initial sample compared to national data (22.4% vs 7.55%, respectively) would likely have further compromised the generalisability of the findings of this study. [10] Furthermore, given the focus of this study on obesity development, the comparability of overweight and obese children to national date (15.2% overweight and 5.5% obese, at 4 – 5 years of age), once underweight children were removed, strengthens the validity of the results. [235, 441] On this note, the over-representation of underweight children in the original sample could be in part attributed to recruitment through social media which biased the sample. This sample bias may also assist to explain rates of breastfeeding longer than 6 months (63.4%) being higher than national average (50% still receiving breastmilk at 6 – 9 months). [442] This risk of sample bias is important to consider in interpreting the results of this study.

4.1.6.5 Conclusion

Environmental factors within the FFE have a clear relationship with the development of childhood obesity and obesogenic behaviours. Consideration of the composite effect of FFE on these outcomes is likely to be important in guiding future research and obesity prevention initiatives by providing a more authentic picture of the FFE children are exposed to, from which more targeted and appropriate strategies can be developed. Examining factors of FFE variables in conjunction with psycho-social variables, as in this study, further articulates the reciprocal influence of these variables on environmental constructs thus assisting in understanding of inequitable distribution of obesity risk. Acknowledging the different and multiple needs of sub-populations in this manner may be used to better tailor obesity prevention interventions.

4.2 Survey 2

4.2.1 Recruitment outcomes - Facebook® advertising

Based on reports generated by Facebook®, exclusively from the $500(AU) budget applied, 29,460 Facebook® users in the target audience ‘engaged’ with the sponsored post, at an average cost of $0.14 per engagement. Of this engagement, 19 people ‘reacted’ to the post (e.g. *Liked* the post), 20 people left comments, 6 people ‘shared’ the post and 709 ‘clicked’ through to the website. Based on these rates, there was roughly a 50% conversion rate from engagement/ ‘click through’ to survey participation.

Of the Facebook® users engaged with the post, 98% were women (2% male). All states of Australia were also reached (2% ACT, 28% NSW, 1% NT, 22% QLD, 9% SA, 3% TAS, 24% VIC, 12% WA). Ninety-seven (97%) of participants engaged with the ad. on mobile devices.

4.2.2 Sample characteristics

On initial screening of the data (n=335), 5 cases were removed as it was indicated that the child met the exclusion criteria based on parent's response to the item 'Does your child have a disability or medical condition which affects their growth, development or metabolism?'

Further details of participants recruited in survey 2 are detailed in table 37 within section 4.2.3 below.

Text and tables within section 4.2.3 are a reproduction of the manuscript published in the journal Nutrition and Dietetics.

The citation is as follows:

Boswell, N., Byrne, R., & Davies, P. S. W. (2018). Prospects for early childhood feeding interventions: An exploration of parent's concerns and acceptability towards social media intervention opportunities. Nutrition and Dietetics. DOI: 10.1111/1747-0080.12502: Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/1747-0080.12502

Contributor	Statement of contribution
Nikki Boswell	Conception and design of the study (60%) Analysis and interpretation of the data (60%) Drafting and critical review of manuscript (60%)
Rebecca Byrne	Conception and design of the project (20%) Analysis and interpretation of the data (20%) Drafting and critical review of manuscript (20%)
Peter Davies	Conception and design of the project (20%) Analysis and interpretation of the data (20%) Drafting and critical review of manuscript (20%)

4.2.3 Paper 5: Prospects for early childhood feeding interventions: An exploration of parent's concerns and acceptability towards social media intervention opportunities.

4.2.3.1 Introduction

Establishing an appropriate feeding dynamic during early childhood is important in reducing child feeding and growth problems, including overweight and obesity which effects around 1 in 4 Australian children aged 4 – 5 years. [8, 10] For this reason, many early childhood feeding interventions aim to support parents establish responsive feeding practices. [8, 250, 308, 312, 326] While these interventions have often shown success in achieving these objectives, evidence of parent's acceptability towards such interventions is limited. [65, 443] Failure to consider parent's acceptability towards intervention design, key messages, and modes of delivery are likely to impede on the overall impact and effectiveness of an intervention and may contribute to participant disengagement and study dropout. [444] Attrition rates in childhood obesity interventions, which range from 27% to 73%, provides some evidence in this regard, and suggest that further understanding of parent's acceptability towards intervention protocols are needed. [365] Increasing researchers understanding of parent's acceptability towards child feeding interventions, in this regard, will allow more appropriate designs, that are likely to have higher rates of engagement, adherence, and consequently, outcome success. [46, 359, 444] Furthermore, given the increasing attention towards internet-based interventions as a potentially efficient means of delivering child feeding interventions, gauging parent's acceptability towards internet-based interventions, as well as parent's concerns regarding such interventions, offers opportunity to better meet the needs of modern parents. [46, 359, 444] Specifically, issues surrounding participants concerns for privacy and social-desirability bias have been flagged as potential barriers in delivering internet-based interventions. [359]

Despite these potential barriers, internet-based technologies appear a plausible means to reach geographically diverse and otherwise vulnerable populations, who are often under-represented in early childhood feeding interventions. [250, 308, 312, 326] For instance, key early childhood feeding interventions in Australia (NOURISH, InFANT [Infant Feeding Activity and Nutrition Trial], and Healthy Beginnings randomised controlled trial) have recruited samples exclusively from Brisbane, Adelaide, Melbourne and Sydney, which reduces the generalisability of the results as regional and remote areas were not represented. [250, 308, 312, 326] Since these interventions were planned in 2007-2008, however, ownership and use of internet-enabled devices has expanded rapidly, with all but 1% of the Australian population having internet-enabled devices and 65% of internet users, using social media. [286, 354] This wide reach of internet-based devices offers new opportunity to reach a diversity of participants and a novel means to engage in intervention delivery. This opportunity was recognized in the InFANT Extend program, an extended version of the InFANT randomised controlled trial, which allowed participants to opt in to an online intervention component that supported engagement with face-to-face program delivery in Melbourne. [321] The social media site Facebook® was specifically used in the InFANT Extend program, as particularly appealing for use in research in Australia as the most popular social media platform, accumulating 95% of social media usage and a consistent distribution of users across metropolitan and regional areas (95% and 97%, respectively). [286, 321, 360]

Given the importance of understanding parent's acceptability towards child feeding interventions and the opportunity for internet-based intervention delivery, this study aims to 1) consult with parents regarding child feeding concerns and behavioural motivations, 2) determine parent's willingness to participate in social media and internet-based interventions, and 3) determine differences in these areas of intervention acceptability based on geographic diversity and other demographic characteristics (income status, parent education and parent age). Consideration will specifically be given to opportunities and concerns regarding intervention via Facebook®, due to its high popularity and significant research potential. The findings of this study will be of benefit in planning future early child feeding interventions in Australia.

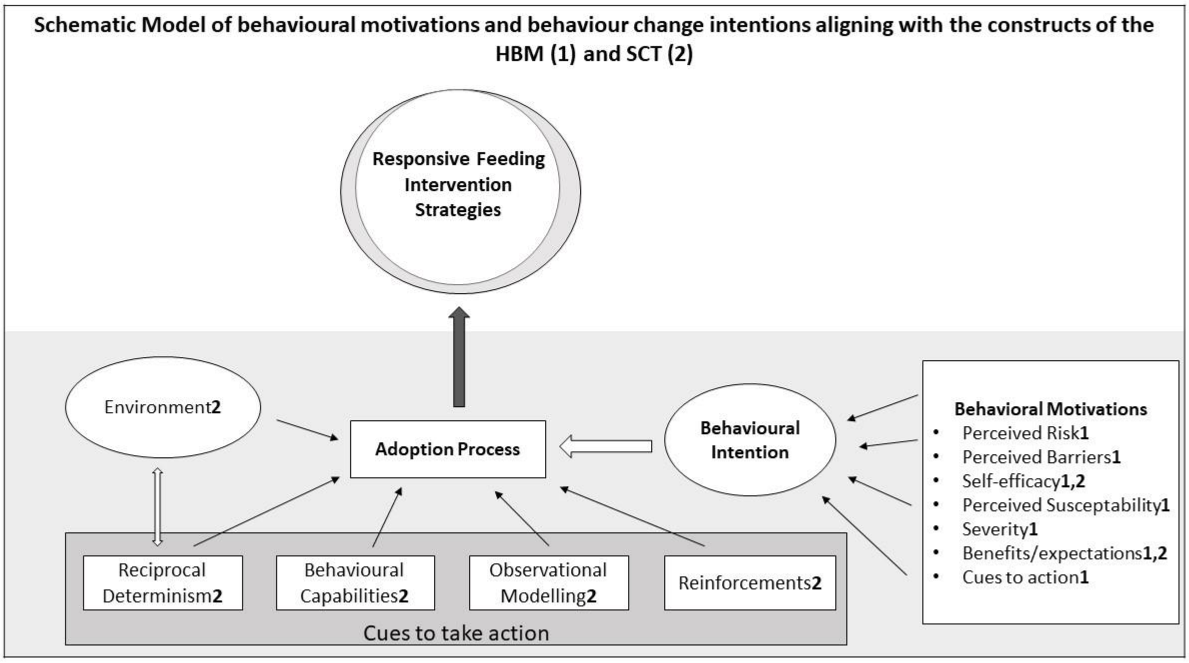
4.2.3.2 Method

Between November 2017 and January 2018, Australian parents of children aged 2.0 – 5.0 years self-enrolled to complete an online, cross sectional survey. The survey was directed towards parents with child feeding concerns through advertising on the social media website Facebook®. The advertisement provided background information about the survey and a link to a website which contained a plain language statement, participant consent form and access to the online survey, hosted by Checkbox®. Children were excluded from this study if parents reported they had a medical condition likely to affect their growth, development or metabolism. Parents with more than one child in the target age were advised to refer to the child whose birthday occurred next. Participants were not provided any incentives for completing the survey.

The health belief model [348] and social cognitive theory [346] were chosen as relevant theoretical frameworks to guide the development of survey items since constructs of the health belief model attempt to understand behavioural motivations (i.e. intentions to perform behaviours based on the perceived susceptibility, severity, and benefits of a behavioural outcome), [348] while the social cognitive theory supports understanding of, and consequently change in, health related behaviours through cues to action.[346] Furthermore, the health belief model and social cognitive theory are frameworks commonly used by researchers across the literature, thus the results of this study will be readily adaptable to future interventions. A schematic model depicting behavioural motivations, behaviour change intentions and cues to action, as they align with the health belief model and social cognitive theory are shown in figure 11, as adapted from Uesugi, et al., (2016). [46]

Figure 11:

Schematic model of behavioural motivations and behaviour change intentions aligning with the constructs of the HBM (1) and SCT (2)



Adapted from the works of Uesugi, et al., (2016)[46] Parents reported the child's gender and age to the nearest half year, parent's gender, highest level of education, marital status (single parent or otherwise), family income (categorical increments from less than $40,000 to more than $150,000), Australian state of residency, and type of residing region (based on rural, remote and metropolitan areas [RRMA] classification). [372] To capture responding parent's behavioural motivations related to participating in a child feeding intervention, parents were asked to identify concerns from a pre-defined list including concerns relating to weight concerns (overweight and underweight), and eating behaviours (overeating, undereating, fussy eating, high intake of discretionary food), as well as perceived barriers in addressing these concerns. Similarly, parents were asked to identify strategies they would be interested in learning to address their concerns, and the delivery mode they would prefer for such a learning experience, from a pre-defined list.

Parent's cues to action were captured in categorical questions reflecting the frequency in which parent's access Facebook®, participate in Facebook® groups, and the type of content they share and engage with on Facebook®. Parents were asked to indicate if they would join a Facebook® group as an intervention platform, if they would be concerned about their privacy in this group, if they believed their honesty in this group would differ to an in-person intervention, the type of content they would access, how often they would expect new content posted, and how quickly they would expect administration of a Facebook® intervention to respond to comments or questions. All survey items were devised for this study based on expert knowledge of child feeding interventions and behaviour change theory. The survey was piloted in a convenience sample of three parents with young children. See table 7 for survey.

Participants were asked to report their receptiveness to participate as an intervention 'champion.' The idea of a 'champion' draws from public health concepts and is a unique construct intended to enhance social media-based interventions by using select participants to support researchers by being highly engaged and facilitating participant engagement with the intervention.

Descriptive and frequency data were created using SPSS v25 (SPSS Inc., Chicago, IL, USA). Confidence intervals (CI) were calculated to provide estimates of sample parameters using standard t-distribution formula based on sample means. All hypothesis assumed a 0.05 significance level and a two-sided alternative hypothesis. Select behavioural motivation variables (parents' child feeding concerns, perceived barriers, intervention strategies of interest, preferred mode of intervention delivery), were analysed to determine differences between geographic region and demographic characteristics. Kruskal-Wallis test, with Dunn's multiple-comparison test using Bonferroni adjustment, was used to determine differences in these behavioural motivation variables and ordinal geographic/demographic variables (region of residence, parent education, and income). Linear regression was used to determine the relationship between parents age with behavioural motivations.

This study has been prepared in accordance with STROBE guidelines (STrengthening the Reporting of OBservational studies in Epidemiology), however, a sample size calculation was not performed. [445] Ethical approval for this research project has been granted through The University of Queensland (approval number 2017001504). In accordance with ethics approval cases with missing data were excluded as considered to have withdrawn from the study.

4.2.3.3 Results

This study recruited 330 Australian parents of children 2.0 – 5.0 years of age. Further descriptive data are reported in table 37.

Table 37: Demographic data (n = 330)		
Child gender	Male	51.8% (171)
Age		
2 years		17.6% (58)
2.5 years		21.5% (71)
3 years		15.5% (51)
3.5 years		12.4% (41)
4 years		11.8% (39)
4.5 years		11.5% (38)
5 years		9.7% (32)
Mean (SD)		3.26 (.97)
Parent gender	Male	3.3% (11)
Parent age (years)	Mean (SD)	34.1 (5.4)
Single parents		9.4% (31)
Income		
Less than $40,000		11.0% (34)
$40,000 - $69,999		16.1% (50)
$70,000 - $99,999		24.2% (75)
$100,000 – 129,999		19.0% (59)

$130,000 or more	29.7% (92)
Australian state	
Victoria	19.7% (65)
New South Wales	23.9% (79)
Queensland	24.2% (80)
Australian Capital Territory	5.5% (18)
Western Australia	10.0% (33)
Tasmania	5.5% (18)
Northern Territory	0.9% (3)
South Australia	10.3% (34)
Region type	
Capital city	36.4% (120)
Metro (population over 100,000)	29.1% (96)
Large rural (population 25,000 – 99,999)	13.9% (46)
Small rural (population 10,000 – 24,999)	11.2% (37)
Large remote (population 5,000 – 9,999)	3.6% (12)
Small remote (population less than 5,000)	5.8% (19)
Parent education	
Did not complete high school	3.3% (11)
Completed year 12 or equivalent	10% (33)
Post-secondary qualifications	25.2% (83)
Bachelor's degree	35.5% (117)
Post-graduate qualifications	26.1% (86)
% (n) reported for dichotomous variables	

Parent reported behavioural motivations (concerns, barriers, intervention strategies and preferences) regarding child feeding, as presented in table 38, indicate that parents' greatest child feeding concern relates to their child being a 'fussy' eater (53.9%). Fewer parents were concerned about their child being overweight (9.4%), compared with underweight (15.2%). Parents reported *time* to be the biggest barrier (50.6%) to them addressing their child feeding concerns, followed by their child having *tantrums* (36.7%), and a lack of *money* (31.2%). Over sixty percent (61.2%) of parents indicated they would like strategies to support their child eat *the right type of food*, 56.4% to *reduce fussy eating*, 53.9% to *prepare quick meals*, 49.4% to support their child eat *the right amount of food*. Further details about desired intervention strategies and differences in behavioural motivations between demographic groups can be seen in table 38.

The largest proportion of parents (32.7%) indicated that a combination of online platforms (e.g. website, email, and/or Facebook® group) was their preferred method of intervention participation, although a combination of online and face-to-face mediums was also preferred by 22.1% of respondents. Forty-three percent (42.7%) of participants indicated that they would participate in an online program (participating once per week), for more than 12 weeks. The preferred duration for a face-to-face only program (participating once per week) was 4 weeks (26.1%), although 30.9% said they would not participate face-to-face (Appendix 6). Additional details reflecting differences in preferred methods of intervention delivery between demographic groups can be seen in table 38. Parents perceived *severity* of their child feeding concern, *importance* in getting support, and *motivation* towards addressing these concerns can be seen in Appendix 6.

Parent reported Facebook® use and acceptability towards social-media based child feeding interventions, are detailed in table 39.

Table 38: Parent reported behavioural motivations (concerns, barriers, intervention strategies and preferences) regarding child feeding based on health belief model constructs.						
			Kruskal-Wallis H			Linear Regression
Concerns			**Region**	**Parent education**	**Income**	**Parent age**
Are you concerned about: (multiple respondent selections)	**% (n)**	**95%CI**	**H (P-value)**	**H (P-value)**	**H (P-value)**	**B* (P-value)**
Your child being overweight	9.4% (31)	6.25 – 12.54	3.25 (.66)	4.25 (.37)	4.89 (.29)	.95 (.16)
Your child being underweight	15.2% (50)	11.32 – 19.07	4.33 (.50)	3.93 (.41)	4.38 (.35)	-.11 (.06)
Your child being a ‘fussy’ eater e.g. eating a limited number of foods, refusing to participate in meals	53.9% (178)	48.52 – 59.27	9.91 (.07)	2.35 (.67)	2.88 (.57)	.02 (.70)
Your child under eating e.g. not eating enough food	24.8% (82)	20.14 – 29.49	5.05 (.41)	7.53 (.11)	1.86 (.76)	-.03 (.58)
Your child overeating e.g. eating too much food	16.4% (54)	12.04 – 20.39	5.50 (.35)	4.20 (.98)	3.86 (.42)	**-.17 (.01)**
Your child not eating enough vegetables or fruit	48.2% (159)	42.8 – 53.59	1.24 (.94)	5.18 (.26)	1.64 (.80)	-.00 (.95)
Your child eating too many discretionary foods	47% (155)	41.61 – 52.38	6.75 (.24)	4.83 (.30)	2.77 (.59)	-.06 (.27)
Perceived Barriers			**Region**	**Parent education**	**Income**	**Parent age**
What barriers might prevent you from making changes to improve these concerns? (multiple respondent selections)	**% (n)**	**95%CI**	**H (P-value)**	**H (P-value)**	**H (P-value)**	**B (P-value)**
Time	50.6% (167)	45.20 – 55.99	3.30 (.65)	7.69 (.10)	8.03 (.09)	**.16 (.01)**
Money	31.2% (103)	26.20 – 36.19	**25.84 (.00)[a]**	**14.63 (.00)[d]**	**59.75 (.00)[f]**	-.10 (.09)
Family support	15.5% (51)	11.59 – 19.40	7.81 (.16)	4.03 (.40)	3.34 (.50)	-.02 (.71)
Confidence	13.6% (45)	9.90 – 17.29	2.46 (.78)	2.20 (.69)	7.69 (.10)	.08 (.18)
Cooking skills	10.3% (34)	7.02 – 13.57	5.11 (.40)	7.69 (.10)	5.16 (.27)	.04 (.51)
Shopping skills	2.1% (7)	0.55 – 3.64	**16.43 (.00)[b]**	**9.48 (.05)[e]**	5.84 (.21)	-.05 (.36)
Knowledge about food and nutrition	12.7% (42)	9.10 – 16.29	2.40 (.84)	9.32 (.06)	5.65 (.22)	-.00 (.91)
Knowledge about child growth and development	12.1% (40)	8.58 – 15.61	11.02 (.06)	2.81 (.58)	4.95 (.29)	-.06 (.28)
Just too hard (self-efficacy)	9.7% (32)	6.50 – 12.89	9.05 (.10)	3.90 (.41)	7.72 (.10)	-.03 (.61)
Don’t know what to do or where to get help	17% (56)	12.94 – 21.05	3.12 (.68)	4.77 (.31)	4.78 (.31)	.49 (.40)
My child will have tantrums	36.7% (121)	31.49 – 41.90	6.72 (.24)	4.42 (.35)	4.01 (.40)	-.06 (.30)

No barriers	18.5% (61)	14.31 – 22.68	**14.55 (.01)[c]**	4.38 (.35)	**10.05 (.033)[g]**	.12 (.09)
Intervention Strategies			**Region**	**Parent education**	**Income**	**Parent age**
Would you be interested in learning strategies and skills to: (multiple respondent selections)	**% (n)**	**95%CI**	**H (P-value)**	**H (P-value)**	**H (P-value)**	**B (P-value)**
Support your child eat the right *amount* of food	49.4% (163)	44.0 – 54.79	4.28 (.50)	1.59 (.80)	**16.80 (.00)[j]**	.01 (.85)
Support your child eat the right *type* of food	61.2% (202)	55.94 – 66.45	3.17 (.59)	6.91 (.14)	1.73 (.78)	-.00 (.91)
Reduce your child's fussy eating	56.4% (186)	51.04 – 61.75	6.81 (.23)	2.16 (.70)	3.79 (.43)	.08 (.12)
Help you create tasty, healthy family meals	48.5% (160)	43.1 – 53.89	1.50 (.91)	7.91 (.09)	5.82 (.21)	-.00 (.98)
Help you create affordable family meals	45.8% (151)	40.42 – 51.17	**13.42 (.02)[h]**	**14.63 (.00)[i]**	**15.35 (.00)[k]**	**-.162 (.02)**
Help you prepare quick meals	53.9% (178)	48.52 – 59.27	2.30 (.80)	3.67 (.45)	3.01 (.55)	.05 (.43)
Intervention Delivery Preference			**Region**	**Parent education**	**Income**	**Parent age**
In thinking about the previous question: What would be the best way for you to develop the skills and strategies selected? (single respondent selection)	**% (n)**	**95%CI**	**H (P-value)**	**H (P-value)**	**H (P-value)**	**B (P-value)**
Website information and materials	21.5% (71)	17.06 – 25.93	**12.81 (.02)[l]**	**14.39 (.00)[m]**	5.28 (.25)	**.12 (.04)**
Email information and materials	8.2% (27)	5.23 – 11.16	5.74 (.33)	3.01 (.55)	3.90 (.41)	**.14 (.01)**
A Facebook® group setting	12.4% (41)	8.84 – 15.94	6.37 (.27)	4.21 (.37)	1.90 (.75)	.05 (.38)
A combination of online platforms only (e.g. website, email, and/or Facebook® group)	32.7% (108)	27.63 – 37.76	7.10 (.21)	2.37 (.66)	3.52 (.47)	-.05 (.30)
A face-to-face education group	3.0% (10)	1.15 – 4.84	6.57 (.25)	1.63 (.80)	2.96 (.56)	.03 (.55)
A combination of a face-to-face group and online platforms (e.g. website, email, and/or face-to-face group)	22.1% (73)	17.62 – 26.57	3.18 (.67)	**16.24 (.00)[n]**	5.57 (.23)	-.08 (.16)

Dunn-Bonferroni Post Hoc – significant differences between (Frequency [Means]):

a. Capital city (17.5% [0.18]) and metropolitan (40.0% [0.40]; P=.00); capital city (17.5% [0.18]) and large rural (53.7% [0.54]; P=.00)
b. Capital city (4.4% [0.04]) and metropolitan (18.9% [0.19]; P=.00);
c. Capital city (27.2% [0.27] and large rural (4.9% [0.05]; P=.02)
d. Did not complete high school (75% [0.75]) and bachelor's degree (23.6% [0.24]; P=.02); Did not complete high school (75% [0.75]) and Post graduate qualification (25.6% [0.26]; P= .04)
e. No significant post-hoc
f. Less than $40,000 (67.6% [0.68]); $40,000 - $69,999 (42.0% [0.42]); $70,000 - $99,999 (42.7% [0.43]); $100,000 - $129,999 (27.1% [0.27]); $130,000 or more (4.3%

[0.04]); Linear trend (P=.00)

g. $40,000 - $69,999 (4% [0.04]) and $130,000 or more (26.1% [0.26], P=.01)

h. Capital city (32.5% [0.32]) and metropolitan (53.3% [0.53]; P=.04);

i. Bachelor's degree (36.4% [0.36]) and Post-secondary qualification (63.3% [0.63], P=.00); Post-graduate qualifications (36.6% [0.37]) and post-secondary qualifications (63.3% [0.63]**,** P=.00)

j. Less than $40,000 (29.4% [0.29]) and $130,000 or more (60.9% [0.61], P=.01)

k. $70,000 $99,999 (54.7% [0.55]) and $130,000 or more (30.1% [0.30]**,** P=.02); Less than $40,000 (61.8% [0.62]) and $130,000 or more (30.1% [0.30], P=.02)

l. No post-hoc

m. Completed year 12 or equivalent (9.7% [0.09]) and post graduate qualifications (8.5% [0.08], P=.03)

n. Did not complete high school (62.5% [0.62]) and post graduate qualifications (14.6% [0.14], P=.02); Did not complete high school (62.5% [0.62]) and bachelor's degree (18.2% [0.18], P=.04)

***B represents standardized regression coefficients**

95% confidence interval (CI) of sample mean assumed a 0.05 significance level and a two-sided alternative hypothesis

Table 39: Parent reported Facebook® use and acceptability towards social-media based child feeding interventions		
How often do you login to Facebook®?	**% (n)**	**95%CI**
Multiple times a day	82.7% (273)	78.61 – 86.78
Once a day	13.9% (46)	10.16 – 17.63
3 or more times a week	1.8% (6)	0.36 – 3.23
1 – 2 times a week	0.9% (3)	-0.11 – 1.91
Less than weekly	0.3% (1)	-0.29 – 0.89
Never	0.3% (1)	-0.29 – 0.89
Would you join a Facebook® group run by a child feeding specialist to get support feeding your child?	**% (n)**	**95%CI**
Yes	86.4% (285)	82.7 – 90.09
Would you be concerned about your privacy if you joined a Facebook® group to get support feeding your child*?	**% (n)**	**95%CI**
Yes	32.4% (107)	27.35 – 37.44
If you were to join a Facebook® group to get support with child feeding*, would you access: (multiple respondent selections)	**% (n)**	**95%CI**
Videos	62.1% (205)	56.86 – 67.33
Text posts	84.2% (278)	80.26 – 88.13
Live streaming	18.8% (62)	14.58 – 23.01
Q & A's with child feeding specialist	63.3% (209)	58.09 – 68.50
Links to website content and articles	84.2% (278)	80.26 – 88.13
None	2.1% (7)	0.55 – 3.64
If you were to join a Facebook® group to get support with child feeding* what type of information would you share? (multiple respondent selections)	**% (n)**	**95%CI**
Photos of you participating in healthy activities	14.2% (47)	10.43 – 17.96
Completed homework tasks	31.5% (104)	26.48 – 36.51
Question related to feeding strategies, child development, nutrition, health eating etc.	83% (274)	78.94 – 87.05
Personal experience	66.4% (219)	61.30 – 71.49
How often would you expect admin of a Facebook® group providing support for child feeding to post new content (text posts, photos, videos, discussion topics)	**% (n)**	**95%CI**

2– 3 times per day	9.4% (31)	6.25 – 12.54
1 time a day	39.1% (129)	33.83 – 44.36
4– 5 times per week	39.1% (129)	33.83 – 44.36
2– 3 times per week	2.4% (8)	0.74 – 4.05
1 time per week	8.5% (28)	5.49 – 11.50
Less than once per week	1.5% (5)	0.18 – 2.81
If you joined a Facebook® group get support with child feeding, how often would you access this group?	**% (n)**	**95%CI**
2– 3 times per day	5.5% (18)	3.04 – 7.95
1 time a day	12.4% (41)	8.84 – 15.95
2– 3 times per week	4.8% (16)	2.49 – 7.10
4– 5 times per week	24.2% (80)	19.57 – 28.82
1 time per week	33.0% (109)	27.92 – 38.07
Less than once a week	20.0% (66)	15.68 – 24.31
How quickly would you expect admin of a Facebook group providing support for child feeding* to answer questions or respond to posts?	**% (n)**	**95%CI**
An hour	3.9% (13)	1.81 – 5.98
A few hours	38.2% (126)	32.95 – 43.44
A day	48.2% (159)	42.80 – 53.59
A few days	8.8% (29)	5.74 – 11.85
A week	0.9% (3)	-0.11 – 1.91
If you were provided with appropriate guidance, would you consider being involved with a research project as a ‘champion’?	**% (n)**	**95%CI**
Yes	23.8% (78)	19.20 – 28.39
No	39.3% (129)	34.03 – 44.56
Maybe	36.9% (121)	31.69 – 42.10
Social desirability bias		
Do you think you would be more or less honest/frank about your personal circumstance and experiences with child feeding in a Facebook® group compared to a face-to-face in a group?	**% (n)**	**95%CI**
More honest/frank in a Facebook® group	26.4% (87)	21.64 – 31.15

Less honest/frank in a Facebook® group	15.5% (51)	11.59 – 19.40
Unsure	17% (56)	12.94 – 21.05
About the same	41.2% (136)	35.88 – 46.51

*The phrase *‘support feeding your child’* - refers to skills, strategies and knowledge provided by a child feeding specialist (University qualified Nutritionist/Researcher) to support your child eat appropriate amounts and types of food, and the supporting skills, strategies and knowledge parents need to select and prepare healthful foods, create positive meal times and eating opportunities.

95% confidence interval (CI) of sample mean assumed a 0.05 significance level and a two-sided alternative hypothesis

4.2.3.4 Discussion

This study provides valuable information regarding parent's behavioural motivations, behaviour change intentions and cues to action related to participation in an early childhood feeding intervention, as aligning with the constructs of the health belief model and social cognitive theory. Briefly, the results of this study indicated the main concern for respondents was their child as a fussy eater (53.9%), with lack of time and child tantrums common barriers to addressing these concerns. Respondents indicated that a combination of online platforms (websites, email, Facebook®) was their preferred method of intervention participation, although, a combination of online and face-to-face methods also had modest preference, particularly among lower educated parents. Participants indicated that they would participate in an online intervention (participating once a week) for more than 12 weeks (42.7%), compared with only 4 weeks (participating once a week) for a traditionally delivered intervention.

More specifically, although the most prominent concern of parents regarding child feeding related to perceptions of their child being a 'fussy' eater, many parents were also concerned about their child eating too many discretionary foods, and not enough fruit and vegetables. While this appears consistent with the recruitment of parents who self-identify as having child feeding concerns, it also appears consistent with national data which shows that Australian children (2 – 18 years) derive around 30% of energy from discretionary food, 99% do not to meet recommended intake of vegetables, and 22% do not to meet recommended intake of fruit. [10] While there is no consensus on the definition of 'fussy' eating, which makes it difficult to ascertain prevalence, parent's *perceptions* of fussiness, as measured in this study, are equally important. [446, 447] That is, perceptions of 'fussiness' are understood to result in alterations in parents-child feeding interactions, such that parents are more inclined to use non-responsive feeding practices which in turn have been seen to increase *fussy* behaviours. [201, 395] Given this, parents who simply *perceive* child feeding difficulties, are likely to benefit from child feeding interventions which focus on use of responsive feeding strategies.

Despite high concerns about childhood obesity within the public health sector, only 9.4% of parents in this study indicated they were concerned about their child being overweight. Low level of parental concern towards child overweight appears consistent with findings across the literature which show that parents are often unaware of child weight issues. [448-451] This can specifically be seen in a study of Australian children aged 5 – 6 years, wherein 89% of parents of overweight children were unaware of their child's weight. [452] Given this low concern for child weight, but high concern for child fussiness, child feeding interventions may benefit from framing core messages around responsive feeding strategies that support parents to manage child fussiness rather than focus directly on child weight. Since responsive feeding practices have been seen to support both healthy weight and increased intake of fruit and vegetables, framing interventions in this way is likely to both appeal to parents while supporting obesity focused outcomes. [65, 268, 443, 453]

The main barriers parents identified in addressing their child feeding concerns in this study were *time*, followed by *child tantrums.* Importantly, these barriers did not differ based on demographic variable (although *lack of time* as a barrier increased slightly with parent age) which indicates the largely universal relevance of these factors to parents of young children. Lack of *money* was also a common barrier which expectedly increased for those of lower incomes and lower education, as well as those residing outside of capital cities. These barriers appear consistent with the strategies and skills parents reported they would be interested in developing. To date, current early child feeding interventions have included components such as positive parenting (encouragement of autonomy, warmth and self-efficacy – as the strongest predictor of health behaviours and an inhibitor of barriers [348]), as relevant to overcoming child tantrums, however, less attention appears to be given to supporting parents overcome food utilization barriers such as time, money and grocery shopping skills. [250, 320] Future child feeding intervention are likely to benefit by framing curriculum to address these barriers, particularly in low socio-economic and populations outside of capital cities.

Further to exploring parent's behavioural motivations and behaviour change intentions, this study explored parent's cues to action within interventions delivered through internet-based platforms, particularly the social media site Facebook®. Specifically, 86.4% of parents indicated that they would participate in a Facebook® group run by a child feeding specialist, with the largest proportion of participants indicating that a combination of internet-based mediums (e.g. website, email, and/or Facebook® group) would be their preferred method of intervention delivery. This preference did not differ based on geographic regions which suggests online interventions are likely to be beneficial in reaching a diversity of participants that is often not possible with traditional interventions. On this note, however, interventions which offer internet-based components (e.g. website and email) in combination with face-to-face elements, also holds much appeal, particularly among lower educated parents. This distinction in acceptability among lower educated parents is likely to be important in tailoring interventions that appropriately support *observational learning*, as a key facet of the social cognitive theory that underpins cues to behavioural action. [346]

In this regard, the preference for internet-based components in intervention delivery, exclusively or in combination with traditional delivery, has benefits for both researchers and participants by supporting opportunity for passive (one-way) intervention content (e.g. articles or videos via websites or emails) that can be accessed by participants when convenient, as well as the opportunity for active (two-way) intervention engagement through the additional use of social media platforms, such as Facebook®, that allow interactions between participants and researchers across geographical boundaries.[321, 353] The desire for such interactive opportunities during an intervention were similarly indicated in a study into parent's acceptability of eHealth interventions (parent with children 4 – 18 years; n=75), which showed that two-thirds of respondents would prefer to interact with other program members and/or staff during an intervention, with social media as a key means to do so. [454] This appeal of internet-based intervention elements, exclusively or in combination with traditional intervention components, is further supported by the findings of a recent systematic review, which suggested that internet-based interventions have the potential for wide reaching public health impact, [344] while an additional review concluded that social media sites offer much promise in reaching target populations and allowing observational learning, without many of the burdens and limitations of traditional intervention, including reliance on geographically related samples. [354, 358]

On this note, the majority of participants in this survey indicated they would actively engage with a Facebook® group intervention by asking questions, sharing personal experiences, and sharing completed homework tasks, as similarly reported in the previously mentioned InFANT extend study. [321] Only 14% of participants in this study, however, said they would share photos of themselves participating in intervention activities. The reluctance of participants in this study to share photos of themselves may be related to concerns regarding privacy, as was a concern for 30% of participants in this survey and has been identified across the literature as a prime limitation of social media interventions. [359, 363] To somewhat overcome this limitation, the idea of an intervention 'champion' was proposed to participants, as a trained and supported participant, that takes the lead in intervention engagement and participation to maximize the potential for *observational* learning and peer *reinforcement*. With almost a quarter of participants in this survey indicating that they were willing to participate as a ‘champion’ and a further 37% indicating they would consider it, this concept holds much promise for Facebook® interventions. This finding is, however, substantially lower than rates reported in a pilot study of Australian parents (of children 6 months to over 2 years of age; n = 34) which showed that 65% of respondents indicated that they were “interested” or “very interested” in becoming a peer nutrition educator, while 76% of respondents were very interested or interested in receiving child nutrition information from a trained peer educator. [279] Finally, over 40% of participants in this survey did not feel their honesty would differ between a face-to-face intervention or a Facebook® based intervention, while only 16% said they would be less honest. These findings are similar to a previous Facebook® based obesity prevention intervention that indicated mothers concerns regarding participation in an online group with people they had not met, varied. [362]

This study provides researchers and practitioners with insight into what makes Facebook® an acceptable and feasible means of delivering early childhood feeding interventions as aligning with the behaviour change constructs of the social cognitive theory. Further to this, this study, provides specific details regarding the child feeding concerns of parents, barriers in addressing these concerns, desirable intervention strategies, and details about preferences for engagement with intervention protocols, as beneficial for future intervention planning. The use of theoretical models throughout this study is a strength of this paper that supports the translation of the results into clinical practice. On this note, the results of this study suggest that parents are adequately motivated to engage in behaviour change strategies initiated within an intervention protocol, in accordance with the constructs of the health belief model, however, care should be taken to support participants overcome barriers that may inhibit their participation. The results of this study additionally suggest that Facebook® interventions can adequately incorporate key elements aligned with the social cognitive theory to facilitate behaviour change, while traditional methods of intervention delivery, particularly in conjunction with online materials, may still hold appeal to some participants.

Despite these strengths, caution should be taken when interpreting these results as the survey developed for this study may have limited validity due to insufficient piloting and lack of sample size calculation. Additionally, multiple comparisons were conducted in this study which may increase the risk of error, although, Dunn's Bonferroni post hoc was used to mitigate this risk. Further to this, the results of this study should be interpreted with caution due to sample bias since participants were recruited through Facebook®, thus indicating they already prefer this social media platform. Despite this potential limitation, Facebook® was selected as a method of recruiting participants due to the ability to instantaneously reach a geographically diverse sample. The high popularity of Facebook® within the target demographic, however, means the results are still likely to be relevant to a large portion of parents of children during early childhood. [286] Additionally, this sample should not be interpreted as representative of the general population, as participants who had concerns with child feeding were specifically recruited. On this note, this study demonstrates the feasibility of online interventions to reach a geographically diverse sample, with all Australian states and RRMA classifications represented. Participants within this study were, however, skewed towards the higher income and higher educated groups.

Based on this study, parents of young children appear to recognise the importance of addressing their child feeding concerns. This recognition is conducive with the behavioural motivations necessary for them to improve their child feeding practices. In consideration of parent's child feeding concerns and identified barriers, future intervention may benefit from framing intervention messages towards management of fussy eating rather than weight-based focuses. Further to this, online intervention components (e.g. website, email and/or Facebook®) appear well accepted by parents of young children and may offer an effective and efficient means of supporting behaviour change across a diversity of geographic regions in accordance with the social cognitive theory. Face-to-face intervention components, however, still hold appeal particularly for lower educated parents.

5.1 Overall discussion

5.1.1 Summary of key findings and contributions to the literature

The results presented throughout chapter 4 have served to fulfil the aims of this thesis; by extending on understanding of the association between children's eating behaviours and obesity status to further determine psycho-social variables related to child weight status (section 4.1.3); by providing broad scoping descriptive data reflecting the FFEs of Australian children during early childhood (section 4.1.4); by deriving *factors* of FFE variables to provide a more authentic picture of ecological exposures as they relate to children's eating behaviours and weight status (section 4.1.6); by statistically detecting the presence of a mediator relationship between food responsiveness, overt restriction and child BMIz, as consistent with the theoretical perspective of the behavioural susceptibility theory (section 4.1.5); and, by determining parents' key child feeding concerns and barriers, as well as their willingness to participate in a child feeding intervention. [2]

These findings begin to address several key gaps in the literature (as presented in section 2.5) by extending on understanding of the relationship between FFE's, children's eating behaviours and obesity status in early childhood in Australia. Considering the current childhood obesity climate, these finding have important implications for public health and for future research. These implications are discussed throughout chapter 5 prior to presentation of an intervention portfolio, as satisfying the final component in the 4-component process in health intervention planning and the action stages of the capacity building framework (figure 12).

<table>
<tr><th colspan="4">Figure 12: Thesis mapping schematic model – Chapter 5</th></tr>
<tr><th>4-component process [45, 46]</th><th colspan="2">Capacity building stages [50]</th><th>Thesis chapter 5 key points</th></tr>
<tr><td rowspan="3">1. Identification of modifiable factors which could be target behaviours

2. Identification of potential mediators

3. Selection and justification of theoretical model</td><td rowspan="3">Assessment

Analysis</td><td rowspan="3">Define needs and analyses problem

Determinant analysis</td><td>Chapter 1: Introduction
• Childhood obesity major public health issue
• Family food environments are the central context in which early childhood obesity emerges

Chapter 2: Literature review
• Children’s eating behaviours associated with child weight status
• Family food environments provide a key context in which childhood obesity develops through interactions with eating behaviours
• Family food environments offer opportunity for intervention directed towards eating behaviours and obesity development
• The social cognitive theory (SCT) and health belief model (HBM) provide a suitable framework for intervention planning
• Technology offers new opportunity for intervention delivery</td></tr>
<tr><td>Chapter 3: Methods
3.2 Survey 1: Eating behaviours & family food environment
3.3 Survey 2: Intervention opportunities & acceptability</td></tr>
<tr><td>Chapter 4: Results
• Survey 1
4.1.3 <u>Paper 2:</u> Eating behaviour traits associated with psycho-social variables and implications for obesity outcomes in early childhood
4.1.4 Family food environment in Australia and children’s eating behaviours
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4.1.6 <u>Paper 4:</u> Family food environment factors associated with obesity outcomes in early childhood</td></tr>
<tr><td rowspan="2">5 Design intervention</td><td rowspan="2">Action

Assessment</td><td>Explore strategy options</td><td>• Survey 2
4.2.3 <u>Paper 5:</u> Prospects for early childhood feeding interventions: An exploration of parent’s concerns and acceptability towards social media intervention opportunities</td></tr>
<tr><td>Implement the strategy portfolio & evaluation (Planning only)</td><td>Chapter 5: Future direction & conclusion
• Technology based interventions hold promise in effecting behavior change
• Parents are accepting of online and Facebook® based interventions
• A 12-week, 6 modules online, family focused intervention has been proposed, encompassing goal oriented, tailored strategies to support parents behaviour change within the FFE to develop healthful eating behaviours in children
• Intention to treat protocol
• Process: via online engagement monitoring
• Impact: Post intervention survey
• Outcome: collected at 6, 12, 18 and 24 months follow up</td></tr>
</table>

In addressing the first aim of this thesis, section 4.1.3 reported that child satiety responsiveness and food responsiveness were the most significant eating behaviours associated with child BMIz in addition to significant co-variates including child age, gender (boy), and parent BMI. These findings are unique as previous research has focused on the individual contribution of eating behaviours to weight status and has not taken into account significant co-variates (demographic and psycho-social), which may have mis-represented relationships between eating behaviours and childhood obesity. [5, 7] For instance, in addition to satiety responsiveness and food responsiveness, previous research has implicated enjoyment of food to be associated with an increased child weight status, while food fussiness is often associated with reduced weight (albeit inconsistently). [5, 7] While these eating behaviours similarly showed relationships with childhood obesity in linear regression analysis in section 4.1.3 (table 14), they were not retained as significant in the final multiple regression model (table 15). These finding suggest that food responsiveness and satiety responsiveness should be prioritised as eating behaviours of significance in childhood obesity prevention. On this point it is worth reiterating that environmental influences explain around 30% of variance in both satiety responsiveness and food responsiveness in young children [165], which has implications in regards to the potential for these eating behaviours to be 'protected' (from homeostatic deviations) through intervention. [113, 165] In promoting appropriate levels of satiety responsiveness and food responsiveness, the concept of a 'competent eater' appears relevant, as someone who is able to respond to innate hunger and satiety signals, and appropriately balance homeostatic and hedonic appetite systems such that a healthy weight is maintained and a healthy relationship with food is established. [311] While there is little evidence to support a direct relationship between 'competent eating' and measures of eating behaviours or weight status in children, this concept is favourable as it similarly recognises that enjoyment of food does not confer a 'risky' food approach eating behaviour and should not be discouraged, and that food fussiness can be reduced through appropriate, responsive, feeding practices. [5, 7, 57, 200, 201, 311]

In focusing on food responsiveness and satiety responsiveness for their positive and negative roles in early childhood obesity respectively, attention should also be given to related psycho-social variables that may highlight vulnerabilities to deviations in eating behaviours and/or highlight factors that could inhibit obesity prevention efforts, such as shorter sleep duration and parental stress which have established relationships with underpinning appetite systems (table 11). This perspective is consistent with that of

Llewellyn, et al., (2017), who proposed that, in accordance with the behavioural susceptibility theory, those predisposed to weaker satiety signals are more likely to overeat in response to external factors such as larger portion sizes and multiple opportunities to eat. [2] The findings of this thesis extend on this by additionally suggesting that those with heightened food responsiveness may be more vulnerable to external food cues and/or that food responsiveness may be more vulnerable to external maladaptation, such as within the context of the FFE.

These potential vulnerabilities surrounding food responsiveness can specifically be seen in section 4.1.5, where it was shown that food responsiveness mediated the relationship between overt restriction and child BMIz (after controlling for co-variates); thus, suggesting that those with tendencies towards heightened food responsiveness may be at greater risk of obesity when exposed to overt restriction. This theory is consistent with the findings of a study which showed that parental restriction was positively associated with child BMI-percentile only in children with two high-risk alleles of the FTO gene, as known to be associated with the tendency to overeat. [172, 258] While this study, like much of the literature, did not make a distinction between parent's use of overt and covert restriction, the findings presented in section 4.1.5 uniquely indicated that overt restriction was specifically important in the relationship between restrictive feeding, eating behaviours and BMIz. Understanding parent's motivations for implementing overt verse covert restriction would further assist in unpacking this relationship and in devising appropriate behaviour change strategies. With this in mind, while it is equally possible that parents implement greater overt restriction in response to a child's heightened tendencies towards food responsiveness, as has been discussed in section 2.3.1.8, it remains logical to recommend that parents avoid use of overt restriction and are given alternative strategies to support their child appropriately balance food approach and food avoidance eating behaviours.

On this note, statistically endorsing the mediating role of food responsiveness in the relationship between overt restriction and childhood weight status (section 4.1.5), provides theoretical support for the use of food responsiveness as an intermediary marker of obesity risk. Thus, interventions that can produce a reduction in food responsiveness and/or an increase in satiety responsiveness (as negatively correlated with food responsiveness), as in line with the perspective of Llewellyn, et al., (2017), are likely to indicate a reduced risk of obesity. [2] Such alterations in children's eating behaviours have been achieved through use of responsive feeding practices implemented during the NOURISH RCT which involved 698 first-time mothers in Australia, as discussed in section 2.4.2. [307] This intervention, however, implemented an anticipatory guidance protocol during the first 18 months of life, which is likely to have differing outcomes in comparison to intervention protocols implemented during the years of early childhood. Studies implemented during early childhood have not, however, been conducted to determine such outcome differences. [307] Further to this, as the results of the NOURISH RCT did not translate into changes in child weight during the follow up period, it remains unknown exactly how much change in food responsiveness and/or satiety responsiveness may be needed to significantly impact on child weight or how long such changes would take to occur. It is similarly unknown if there are differences in the adaptability of food responsiveness and/or satiety responsiveness due to psycho-social and demographic variables. Answering these questions requires longitudinal experimental data, as proposed in section 5.2.

While the distinct role of overt restriction in relation to food responsiveness and child BMIz has been highlighted (section 4.1.5), results presented in section 4.1.3 further show food responsiveness to positively relate to single-family meals, parent's use of reward for behaviour, and parent's negative nutrition related beliefs (thus suggesting an increased obesity risk). Conversely decreased satiety responsiveness was associated with single-family meals, parent's use of reward for behaviour, a structured meal setting, frequent family meals, family and child use of TV/devices during meals, and the belief that healthy food is expensive (similarly suggesting an increase in obesity risk). Although these findings are generally consistent with the literature, single-family meals, structured meal timing, and frequent family meals are widely accepted to be related to a reduced obesity risk, as in contrast to the findings in this section. [37, 38, 296, 297]

In interpreting these contradictions, it should firstly be considered that the analysis used in section 4.1.3 may increase the risk of type 1 error (as discussed in section 5.1.2). It should additionally be considered, that these elements of the FFE do not occur in isolation from other FFE variables and as such, the collective contributions of FFE variables to food responsiveness, satiety responsiveness and obesity status, as investigated in section 4.1.6, may provide a more authentic *picture* of the ecological exposures experienced by children. This type of relationship between FFE variables collectively had scarcely been seen within the literature and this was the first study to our knowledge within an Australian sample.

From this perspective, the FFE factor characterised by parent's 'Negative [non-responsive] feeding strategies' (including reward for eating, reward for behaviour, persuasive feeding and overt restriction) expectedly related positively to child food responsiveness and food fussiness, as well as child BMI category (section 4.1.6, table 34 – 35). The positive loading of a structured meal setting onto this factor was, however, unexpected based on positive relationships between this variable and reduced obesity status seen in other studies. [244] Although the literature has previously shown such non-responsive feeding strategies to have a negative impact on a child's ability to act as a competent eater, as previously defined, these findings additionally show that such feeding practices tend to occur together and are likely to have a cumulative impact on eating behaviours and consequently obesity risk. Thus, for example, while a structured meal setting, when considered in isolation from other FFE variables, appears to have a positive association with children's eating behaviours, when considered in conjunction with other non-responsive feeding strategies, appears to relate detrimentally to a child's obesity risk. This perspective seems somewhat consistent with the concept that the *quality* of family meals and the mealtime interactions are more important to obesity risk than simply the frequency of family meals, as presented in section 2.3.1.1.

What is of further interest regarding this FFE factor (Negative feeding strategies, as presented in section 4.1.6), is that although parent's use of non-responsive feeding strategies related positively to child food responsiveness, they related negatively to parent BMI. This negative relationship between parent BMI and non-responsive feeding strategies may explain the unexpected relationship between parent's BMI and child food responsiveness/satiety responsiveness found in section 4.1.3. That is, in section 4.1.3 the findings indicated that parent's BMI related negatively to child food responsiveness (e.g. as parent BMI increased, child food responsiveness decreased), while child satiety responsiveness related positively to parent BMI (e.g. as parent BMI increased child satiety responsiveness increased). This would suggest a child of a healthy weight parent to be at an increased risk of obesity based on the direction of the associations between eating behaviours and BMI. This, however, is in contrast to the positive (albeit small) relationship between parent BMI and child BMIz also detected in these data (table 15) and as widely accepted across the literature, as logically underpinned by both shared genetics and shared environment. [63, 455] Consequently, since children appear to display eating behaviours opposing their parent's obesity tendencies (e.g. not reflective of either shared environment or genetics), this unexpected relationship between children's eating behaviours and parent BMI may logically be explained by elements of non-shared environment, such as non-responsive feeding strategies, as evident in section 4.1.6. In attempting to understand this phenomenon further, it appears important to consider parent's motivations in implementing non-responsive feeding strategies such that interventions can be effectively designed to target these behaviours. Studies that have examined parent's use of feeding strategies in twin studies provide some insight into parent's motivations, with authors suggesting that parents may use differential restrictive feeding practices when they have differential concern for their child's weight, or may implement differential pressure to eat and instrumental feeding to 'correct' their child's *fussy* eating behaviours. [200, 201] The same logic is likely to apply to children considered by parents to be highly food responsive, as discussed. Since the relationship between parent BMI and child eating behaviours has received less attention, the unexpected direction of this relationship between parent weight and child eating behaviours was a unique and intriguing finding of this research that requires further attention.

In this regard, it seems logical that parents are likely to benefit from increased understanding of developmentally normal and appropriate eating behaviours in children and the use of feeding strategies that are appropriate to support children to maintain levels of food approach and food avoidance eating behaviours that satisfy energy homeostasis. As highlighted in section 4.1.6, however, a 'one-size fits all' approach to intervention protocol is unlikely to be effective in preventing childhood obesity. That is, in section 4.1.6 it can be seen that two vastly different FFE factors showed positive relationship with child BMI category. Unlike the FFE factor 'Negative feeding strategies,' as discussed to be characterised by non-responsive feeding practices, the FFE factor 'Parent's negative nutrition related beliefs,' was characterised by parent's beliefs about the taste, convenience and cost of healthy food, and the availability of fruit and vegetables within the home. Additionally, parent's use of 'Negative feeding strategies' was not associated with any demographic variables, while 'Parent's negative nutrition related beliefs' was associated with variables reflective of a low SES profile (e.g. low income and breast feeding less than 6 months). Given this, while the value of responsive feeding practices may be a generically important message to communicate to parents, supporting parents in low SES areas to develop more healthful nutrition related beliefs (as motivators of nutrition related health behaviours), has the potential to be additionally beneficial in this population group. While it is not possible to change the SES of individuals directly, and political changes to improve equity are beyond the scope of this thesis, it is likely that developing food utilisation skills and levels of parent self-efficacy would be beneficial intervention strategies in this context, such that healthy, affordable and pleasant tasting meals can be created from available resources. The opportunity to deliver such tailored intervention strategies are discussed in section 5.2.

This concept that ‘a one-size fits all’ approach to obesity prevention intervention is insufficient to address the complexities of obesity is further evident in the results of section 4.2.3 with regards to intervention delivery. Results in this section indicated that, despite the generally high level of acceptability towards child feeding interventions delivered via a combination of online platforms (websites, email, Facebook®), parents with lower levels of education had significantly higher preference for a combination of online and face-to-face methods of intervention delivery. This distinction in acceptability among lower educated parents is likely to be important in tailoring interventions that appropriately support *observational learning*, as a key facet of the social cognitive theory that underpins cues to behavioural action. [346] Despite this difference in preference for face-to-face elements, the acceptability of online intervention components across all demographic groups is also an important finding of this research given the potential of online interventions in overcoming many of the burdens and limitations that have traditionally impeded intervention delivery. That is, internet-based intervention components offer researchers and participants flexibility in time commitment through asynchronous engagement. This benefit of online interventions may assist in overcoming issues with attrition, which in traditional paediatric weight management programs has ranged from ~30% to ~70%, commonly due to scheduling conflicts or the program being offered too far from home. [365] On this note, *time* was the most common barrier to participating in a child feeding intervention reported in section 4.2.3 and was seen as the most frequently reported reason (60%) that mothers of young children did not consent to participate in the second stage of the previously discussed NOURISH RCT. [456]

The results presented in section 4.2.3 additionally showed that, despite high concerns about childhood obesity within the public health sector, only 9.4% of parents participating in survey 2 indicated that they were concerned about their child being overweight, while over 50% were concerned about their child being a fussy eater. Although this finding is somewhat consistent with the recruitment of participants into this survey, low level of parental concern towards child overweight is also consistent with findings across the literature among samples of children ranging from 12 months to 6 years of age. [448-452] This information is again useful in planning future obesity prevention interventions in that, parents may be more inclined to participate in an intervention marketed towards addressing fussy eating behaviours rather than obesity prevention. Given that the use of responsive feeding practices are understood to be beneficial in addressing both fussy eating and obesity, this marketing approach has much merit. [200, 201] On this note, directing obesity prevention intervention attention towards children's eating behaviours as a surrogate endpoint, is a novel concept that is currently under explored, particularly during the years of early childhood, despite strong theoretical justification. As discussed in section 2.4.2, using eating behaviours as a surrogate endpoint in obesity prevention intervention holds much appeal for both researchers and participants. For researchers, the use of children's eating behaviours as a surrogate endpoint is likely to overcome time burdens needed to see changes in child weight as well as overcome burdens related to the need to physically measure child anthropometrics which is time consuming and requires participants to be within geographic proximity of researchers. In this regard, focusing on children's eating behaviours as a surrogate intervention endpoint is highly compatible with an internet-based intervention protocol as parents are able to provide subjective measures of eating behaviours through validated survey tools administer remotely. This accessibility of children's eating behaviours as an intervention outcome measure is likely to assist in overcoming issues of homogenous samples, as have dominated the current literature (section 2.3.3). Full details reflecting opportunities to apply this novel approach to childhood obesity prevention intervention are detailed in section 5.2.

Table 40: Summary of key findings
Research aim 1: *To determine psycho-social variables (low income status, single-parent status, short sleep duration, parent's depression, stress and anxiety, and breastfeeding duration) associated with children's eating behaviours and the relationship these behaviours have with BMIz in Australian children during early childhood* **(section 4.1.3)** • When examined in multiple regression, the only eating behaviours associated with child BMIz were food responsiveness and satiety responsiveness (B=0.188, p=0.020 and B=-0.260, p=0.013, respectively). Additional variables associated with child BMIz included being a boy (B=0.561, p=0.000), child age (B=-0.204, p=0.001),

and parent BMI (B=1.413, p=0.012).

- Enjoyment of food was associated with child sleep duration (B=0.105, p=0.000), single parent status (B=0.234, p=0.001), breastfeeding less than 6 months (B=-0.136, p=0.004), and parental depression (B=-1.343, p=0.009).
- Food fussiness was associated with child sleep duration (B=-0.133, p=0.000), parental depression (B=2.711, p=0.000), single parent status (B=0.323, p=0.000), child age (B=0.079, p=0.014) and breastfeeding less than 6 months (B=0.139, p=0.002).
- Food responsiveness was associated with parental stress (B=0.225, p=0.000), child age (B=0.079, p=0.003), and parent BMI (B=-0.494, p=0.041).
- Satiety responsiveness was associated with parent BMI (B=0.649, p=0.001), sleep duration (B=-0.060, p=0.000), and child age (B=-0.059, p=0.004).
- Slowness in eating was associated with parental stress (B=0.158, p=0.000).

Research aim 2: *To provide broad scoping descriptive data reflecting the FFE of Australian children during early childhood, as conceptualised within the socio-ecological model, and to extend on what is currently understood about the relationship between FFE variables and children's eating behaviours* **(section 4.1.4)**

- Description of FFE's in Australia:
  - Sixty percent (60%) of families report using TV during meals (*sometimes* or 'yes')
  - Thirty-two (32%) of parents report adult use of electronic devices during meals (*sometimes* or 'yes')
  - Eleven (11%) of parents report child use of electronic devices during meals (*sometimes* or 'yes')
  - Cooking and food storage facilities within the home were considered suitable by 92% and 91% of parents, respectively.
  - 77% of parents strongly agreed they had sufficient money to buy food each week.
  - 93% of parents reported that they *always* had fruit and vegetables available within the home.
  - 92% and 97% of parents reported their cooking skills and shopping skills as *good* or *very good*, respectively.
  - 52% of parents agreed or strongly agreed that 'healthy eating was expensive.'
  - 16% of parents agree or strongly agree that 'it takes too long to prepare a healthy meal.'
  - 6% of parents agreed or strongly agreed that 'healthy food doesn't taste good.'

- 72% of parents rated nutrition for their family as 'important.'
- 82% of parents obtain nutrition information from the internet.
- Parents generally have high levels of nutrition knowledge (mean 86% correct)
- Families shared 13.5 family meals together per week.
- Parents reported a moderate use of food as a reward for eating and food as a reward for behaviours, and slightly high use of persuasive feeding techniques, covert restriction, overt restriction, structured meal timing, and structured meal setting.
- Parent's depression, anxiety and stress scores corresponded with normal ranges for 95%, 98% and 98% of participants, respectively.

- Variations in eating behaviours:
  - Enjoyment of food and food fussiness varied most within the FFE, while satiety responsiveness varied the least.
  - Food responsiveness appears to vary moderately within the FFE, particularly in relation to reward for behaviour, overt restriction, and parent's nutrition related beliefs. Interestingly food responsiveness scores were higher with increasing income sufficiency but was not related to TV viewing or electronic devices as expected.
- Overt restriction was the only FFE variable that showed relationship with child BMIz.
- Despite being used equally by parents (based on mean scores), covert restriction was not related to any eating behaviours.

Research aim 3: *To statistically examine the intermediary role of children's eating behaviours in child (2.00 – 5.00) BMIz in accordance with the behavioural susceptibility theory* **(section 4.1.5)**

- The relationship between overt restriction and child BMIz was mediated by food responsiveness, explaining 5.75% of the relation, after controlling for co-variates.
- This study is the first to our knowledge to statistically confirm the intermediary role of eating behaviours (food responsiveness) in childhood obesity, in line with the behavioural susceptibility theory.
- Overt and covert restriction appear to have distinctly differing relationships with children's eating behaviours and obesity status.

Research aim 4: *To examine the relationship between collective factors of family food environment variables with child eating behaviours and BMI categories, as a more authentic reflection of ecological exposure during early childhood in Australia* **(section 4.1.6)**

- Eight FFE factors were derived.

• Scores for factors ‘Negative feeding strategies’ and ‘Negative nutrition related beliefs’ increased with child BMI category, while scores for factors ‘Use of TV and devices’ and ‘Parent’s nutrition knowledge’ decreased. • The FFE factor ‘Negative feeding strategies’ was positively associated with food fussiness, food responsiveness and slowness in eating, and negatively associated with parent BMI score. • The FFE factor ‘Negative nutrition related beliefs’ was positively associated with food responsiveness, as well as positively with parent BMI, children gender (boy), breastfeeding less than 6 months, and low-income status. • The FFE factor ‘TV and devices’ was positively associated only with residing in a capital city. • The FFE factor ‘Parent’s nutrition knowledge’ was negatively associated with slowness in eating, breastfeeding less than 6 months and low-income status, and positively associated with parent stress and residing in a capital city.
Research aim 5: *To determine parent’s acceptability towards, and behaviour change intentions within, a child feeding intervention, with consideration explicitly given towards acceptability of online modes of intervention delivery as a plausible means to reach a diverse sample of participants* **(section 4.2.3)** • 54% of parents were concerned about their child as a fussy eater. • 48% of parents were concerned about their child not eating enough fruit and vegetables. • 47% of parents were concerned about their child eating too many discretionary foods. • 9% of parents were concerned about their child being overweight. • Time (50%), child tantrums (37%) and money (30%) were the most common barriers reported by parents in addressing their concerns. • A combination of online platforms (e.g. website, email, and/or Facebook® group) was the preferred means of intervention delivery by the largest portion of parents (33%), followed by a combination of face-to-face and online (22%). • Lower educated parents had significantly higher preference for a combination of face-to-face and online intervention platforms. • Money and grocery shopping skills as barriers to addressing child feeding concerns were significantly lower in capital cities and in higher educated parents.

5.1.2 Strengths and limitations

In interpreting the results of this thesis consideration must be given to the strengths and limitations of the methodological processes implemented. These considerations are discussed below.

5.1.2.1 Benefits and limitations of Facebook® for recruitment

Given that Facebook® is currently the most popular social media platform in Australia, with high usership among parents of young children, as discussed in section 2.3.2.2, it was used as the exclusive method of participant recruitment in this thesis (survey 1 and survey 2). This method was highly effective in instantaneously reaching a diversity of participants to successfully recruit adequate research samples (as discussed in section 5.1.2.2 and 5.1.2.3 relative to each survey). Despite this benefit, this method of recruitment also had distinct limitations that warrant discussion. Primarily, as Facebook® was used as the exclusive recruitment method, the risk of recruitment bias must be considered. Firstly, despite Facebook® being reported to be used by over 65% of Australians adults under 40 years of age (as is the key demographic of parents with young children), with relatively equitable distribution across geographic regions and income groups [286, 287], Facebook® users may differ to non-Facebook® users in other ways. Secondly, as snowball sampling is an incidental occurrence of Facebook® recruiting (as described in section 2.4.5.4 to involve recruitment of participants facilitated by other participants through explicit and implicit invitation to the research project [354]), the sample may have been biased towards participants of similar demographics, as described by Kosinski, et al., (2015). [457] The risk of snowball sampling is evident in recruitment of survey 1 with 63 people sharing the recruitment post (section 4.1.1). Finally, bias in recruitment may have occurred since participants in survey 1 and survey 2 were self-selecting. These elements of recruitment bias may have resulted in a sample that fails to represent the general population of Australian parents with young children. Specific details regarding the generalisability of the samples recruited in survey 1 and survey 2 are discussed in section 5.1.2.2 and section 5.1.2.3, respectively.

5.1.2.2 Strengths and limitations of survey 1

While the ability to make conclusions about the direction of the relationships identified in survey 1 is limited due to the cross-sectional nature of the study, the large and geographically diverse sample of participants recruited is a noteworthy strength. All states in Australia have been represented in this sample, although comparably to national data

Victoria, New South Wales and the Northern Territory are slightly under represented ([sample v national] 17.7% V 25.0%, 25.2% V 32%, and 0.5% V 1.02%, respectively), while Queensland, Australian Capital Territory, Western Australia, Tasmania and South Australia are slightly over represented ([sample v national] 30% V 20.1%, 2.9% V 1.64%, 12.5% V 10.89%, 3% V 2.17% and 8.4% V 7.1%, respectively). [409] Rates of single parents in this survey are similarly comparable to the 15% reported in national data, whilst distribution of participants in the high and middle income groups in this survey are similar, low income families are underrepresented. [235] This, however, could be due to the particularly low cut off for the low-income category used in this survey.

Additionally, although anthropometric data were parent-reported, once cases of 'unlikely' anthropometric data were removed, rates of overweight (11.1%) and obese (6.5%) children in this survey were similar to those reported nationally, wherein 15.2% of Australian children 4 - 5 years of age are overweight and 5.5% are obese. [10] Rates of underweight children in this sample (22.4%), however, are likely over-represented compared with national data (7.55%), which similarly reduced rates of normal weight children in this sample (59.9%) compared with nations data (67.75%). [10] While it is possible that parents under-reported their child's weight, as is common, or errors were introduced due to reporting child age to the nearest year or half year, it is also possible that parents of underweight children were seeking support through online platforms, as was the recruiting process for this survey, thus were more likely to self-enrol. [410] On this note, although self-reported anthropometric data are not as accurate as clinically measured data, a recent meta-analysis (23 studies, 48,213 participants, mean age of 12.7 years) of the accuracy of using the self-reported BMI for screening children and adolescents for overweight and obesity status, concluded self-reported data (although not specifically parent-reported) had good overall performance (sensitivity, 0.76; high specificity, 0.96) and is a viable alternative when direct measurement of BMI is not available. [392]

On this note, since participants self-selected to enrol in this survey, the fact that mothers responded substantially more than fathers, may reflect the dominance of women in childcare and child feeding, as consistent with the literature. [231-235] Alternatively, the under-representation of fathers in this sample may suggest that fathers are simply less inclined to self-select to participate in this type of research. Additionally, in survey 1 parents were not asked to identify if they were the primary caregiver for the child, if the child resided with them, or if they were genetically related to the child, which could bias the data reported as well as its interpretation. Further to this, parents were not asked if their child was attending any care outside the home (e.g. daycare, pre-school), which could impact on how parents construct other elements of the FFE, particularly parent feeding strategies, the frequency of family meals, and the role models' children are exposed to. This is a significant limitation of this research as well as across the literature generally, with no studies identified that examine parent's use of outside of home care, in addition to elements of the FFE such as child feeding practices/parenting style, along with child eating behaviours and/or weight status.

In this regard, this study makes valuable contributions to the literature by uniquely examining children's eating behaviours and weight status along with a broad range of variables conceptualised within the FFE. This range of variables has allowed a thorough *picture* of FFEs of Australian children to be drawn (section 4.1.4) as well as examination of collective contributions of FFE variables to relationships with eating behaviour and weight status (section 4.1.6). While the analysis of these variables conducted in section 4.1.4 increased the risk of type 1 error due to repeat analysis, the factor analysis conducted in section 4.1.6 provided a more robust interpretation of the data. It should further be cautioned on this note, however, that serval items within survey 1 were developed for this study and had not previously been validated (Appendix 5). Although piloting was undertaken with a small convenience sample, additional steps are needed to validate these survey items for future research. Despite this limitation, where possible, the use of well-established and validated tools to measure children's eating behaviours (CEBQ), parent's feeding practices (FPSQ-28), and parent's stress, depression and anxiety (DASS-21), is a noteworthy strength. [35, 67, 243, 244, 373] Specifically, the FPSQ-28 was a particularly advantageous instrument to use since both overt and covert restriction are measured with this instrument. Exploration of the distinct relationships of overt and covert restriction with children's eating behaviours was highlighted in the literature as an important area for additional research. While this thesis has addressed this important area for future research, given the cross-sectional nature of the analysis, additional longitudinal studies are still required that can further determine the direction of relationships detected. Further to this, studies which additionally explore children that may be particularly vulnerable to differing feeding practices (due to psycho-social and/or genetic variances) are needed. As are studies which aim to additionally understand parent's motivations in implementing different feeding practices.

5.1.2.3 Strengths and limitations of survey 2

Similarly with survey 1, the results of survey 2 should be interpreted with caution due to the cross-sectional nature of the data collected. Further to this, survey 2 is additionally limited due to insufficient piloting and lack of sample size calculation. Despite these limitations, all states in Australia have been represented in this sample, although comparably to national data Victoria and New South Wales are slightly under represented ([sample v national] 19.7% V 25.0%, and 23.9% V 32%, respectively), while Queensland, Australian Capital Territory, Tasmania and South Australia are slightly over represented ([sample v national] 24.2% V 20.1%, 5.5% V 1.64%, 5.5% V 2.17% and 10.3% V 7.1%, respectively). [409] The Northern Territory and Western Australia are, however, comparable ([sample v national] 0.9% V 1.02% and 10% V 10.89%, respectively). [409] Rates of single parents in this survey are slightly less than the national rate ([sample v national] 9.4% V 15%), whilst distribution of participants in higher income groups ($70,000+) appears overrepresented compared with lower income groups. [235] Lower educated parents were also underrepresented in this sample, with 61.6% of participants having bachelor's degree or higher qualifications. The tendency of higher income and higher educated participants to self-select as research participants, despite being expected, is likely to bias results of this study.

On this note, it should be emphasised that, unlike survey 1 that aimed to recruit a general sample of parents with children 2.0 - 5.0 years of age (excluding children only based on parent report of medical conditions or disability likely to impact growth, development or metabolism), survey 2 recruited a sample of parents with children 2.0 - 5.0 years who self-identified as having child feeding concerns (whilst also excluding children only based on parent report of medical conditions or disability likely to impact growth, development or metabolism). This recruitment may influence the generalisability of the results of this survey. Similarly, since participants were recruited through Facebook®, data related to preferences towards Facebook® as a platform for intervention delivery is likely to be biased since participants already had a preference for this platform. Despite these limitations, this survey provides researchers and practitioners with unique insight into what makes Facebook® an acceptable and feasible means of delivering early childhood feeding interventions as aligning with the behaviour change constructs of the SCT. Further to this, this study provided specific details regarding the child feeding concerns of parents, barriers in addressing these concerns, desirable intervention strategies, and details about preferences for engagement with intervention protocols, as beneficial for future intervention planning (section 5.2). In this regard, the use of theoretical models (SCT and HBM) throughout this survey is a strength of this study that supports the translation of the results into clinical practice, as discussed in the following section.

5.1.3 Research direction

The implications of the findings of this thesis for public health practice and future research are discussed in the following section.

5.1.3.1 Public health

Given that childhood obesity is a key issue of public health priority it is important that public health messages, perspectives and approaches evolve in accordance with the expanding field of research. In this regard, public health attention largely focuses on *what* children are fed, as a means of promoting healthy growth and development, while neglecting the importance of *how* children are fed. This importance of *how* children are fed within the context of the FFE is a key output that can be interpreted from the results presented in this thesis. [399]

Current guidelines around childhood obesity prevention remains focused on the types of foods eaten from the perspective that nutritional quality underpins the disequilibrium in energy homeostasis that results in obesity development. [22, 458] While there is no doubt that compromised nutritional quality is also a public health concern, children's eating behaviours play a critical role in energy homeostasis via both the quantity and quality of foods eaten. [5, 7, 67] Furthermore, the results of this thesis indicate that parents generally have good nutrition knowledge and consider their food utilisation skills to be good (section 4.1.4), however, national data indicate that 95% of children (2-18 years) fail to meet the recommended intake of fruit and vegetables, 30% of children's (2 – 3 years) energy comes from discretionary foods, and over 20% of young children in Australia are overweight or obese. [10, 11, 459] Despite this intake of discretionary foods being lower than what was reported in 1995, rates of overweight and obesity have continued to rise. [10, 11, 459] This disjoint between nutrition knowledge and food utilisation skills and health-related outcomes strongly indicates alternative strategies and public health messages are needed.

Parents/carers, health-care providers and public health professionals need to gain an understanding of developmentally normal and appropriate eating behaviours and require evidence based guidelines detailing the strategies and practices that should be implemented within the context of the FFE (and at a macro-level) to support children appropriately balance eating behaviours (namely satiety responsiveness and food responsiveness) such that energy homeostasis is maintained while making food selections consistent with current dietary guidelines. [311, 399] Although the World Health Organisation's (WHO's) 'Report of the commission on ending childhood obesity,' specifically promotes public awareness campaigns and the dissemination of information to increase awareness of the consequences of childhood obesity, parents are often unaware that their child is overweight, thus shifting attention from weight to eating behaviours is likely to assist engage parents and increase dialogue between parents and health care providers by removing weight based stigmatisation and/or misconceptions. [313, 314, 410, 452, 460-462] Reducing such stigma around weight must similarly be a public health priority, with emphasis on eating behaviours a plausible way to start to address this issue. Similarly, shifting the focus from weight to eating behaviours in future obesity prevention interventions is likely to reduce parent's reluctance to participate in interventions due to perceived stigma around weight and issues of social desirability. [462] Further to this, a shift in intervention focus from weight-based outcomes (e.g. BMI) to eating behaviour outcomes is likely to mean that intervention effect can be measured within a shorter duration since changes in eating behaviours theoretically can be achieved prior to significant changes in weight status – this is particularly appealing for public health funders. The statistical confirmation of the mediating role of food responsiveness in the relationship between parent's use of overt restriction and child weight status, as presented in section 4.1.5, further justifies this focus on eating behaviours (food responsiveness) as an intermediary marker of obesity status.

In further support of this perspective, recent clinical guidelines presented by The European Society of Endocrinology and the Paediatric Endocrine Society recommend that attention be directed towards identification of eating cues in the child's environment (as suggested in these guidelines to include boredom, stress, loneliness, or screen time) in the treatment of obesity. [463] In this regard, the outputs of this thesis are of clear public health importance through exploration of variables within the FFE that, individually and collectively, are likely to act as eating cues and consequently contribute to deviations in children's eating behaviours. Further to this, the works of this thesis contribute to preliminary identification of individual vulnerability to eating cues or deviations in eating behaviours due to genetic and/or psycho-social factors. These vulnerabilities, while not acknowledged in the guidelines presented by The European Society of Endocrinology and the Paediatric Endocrine Society must be taken into consideration in future public health initiatives.

In acknowledgement of such vulnerabilities to deviations in eating behaviours (section 2.2.3 and section 4.1.3) and variations in environmental context in which such food cues are embedded (section 4.1.6), it is unlikely that a 'one size fits all' approach to obesity prevention will accommodate the differing needs of sub-population groups. This prospect is further evident in consideration of the results presented in relation to survey 2 (section 4.2.3), wherein it was seen that parents with lower education had greater preference for interventions that include face-to-face components. Parents from differing income groups and regions of residence also identified different barriers to participation in child feeding interventions and desired interventions focused on differing child feeding skills and strategies (section 4.2.3). In noting this, consideration must subsequently be given to how to tailor or differentiate public health initiatives and future interventions (as discussed in section 2.4.3.2.2) to participants or sub-population group needs while maintaining intervention integrity and measurability. Key public health recommendations are summarised in table 41.

Table 41: Key public health recommendations/guidelines for parents
1. Implement responsive feeding practices, that avoid use of overt restriction, pressure to eat, bribes and rewards. 2. Trust your child's appetite and respond appropriately to signs of satiety. 3. Create a routine for regular shared meals, that is structured, predictable and relaxed. 4. Implement authoritative parenting such that you are responsive to your child's emotional needs while having age appropriate standards (setting limits, enforcing boundaries). 5. Turn off devices during meals and positively engage with family members. 6. Ensure healthy food selections are available within the FFE; use covert restriction of less nutritious foods by minimising availability within the home. 7. Role model healthy food selections and responses to hunger and satiety signals. 8. Develop strategies to appropriately manage stress, depression and anxiety; seek professional support where needed. 9. Develop grocery shopping and cooking skills to support nutrition food choices compatible with available home resources (money, food storage, preparation facilities).

5.1.3.2 Future research

In addition to these implications for public health the works of this thesis have implications for future research.

While it is theorised that changes in children's eating behaviours can be achieved prior to statistically significant changes in child weight, it remains unclear how quickly food responsiveness, or other eating behaviours, can be changed and/or homeostatic eating behaviours can be achieved in response to changes within the FFE context. The degree of change in these eating behaviours that will significantly impact on child weight and over what duration this might occur; and, if there are differences in the adaptably of eating behaviours (particularly food responsiveness and satiety responsiveness) due to genetic, psycho-social and demographic variables. The results from the NOURISH RCT provide preliminary evidence in this regard, by showing that at 2 years of age, children that had received an anticipatory guidance intervention to support the establishment of complementary feeding practices in infancy, had higher satiety responsiveness, lower emotional overeating and lower fussiness compared with control children (3.12 v 3.01 on the CEBQ sub-scale, p= 0.03; 1.48 v 1.60 on the CEBQ sub-scale, p= 0.009; 2.46 v 2.62 on the CEBQ sub-scale, p= 0.01, respectively). [308] As previously mentioned, at 3.5 years follow up intervention children also had lower food responsiveness and higher satiety responsiveness. [233, 250, 307] While these changes show promise in terms of intervention success in influencing eating behaviours, they were not seen to translate into changes in child BMI over the follow up period. This could be because infants enrolled in the trial were not necessarily overweight to begin with and eating behaviours had been exposed to fewer influences within the FFE context (due to the anticipatory guidance protocol). Thus, the relevance of the research questions previously posed remains pertinent regarding adapting eating behaviours in older children (2 – 5 years), once established in the context of the FFE, and in children who may already be overweight or obese. Answering these questions requires longitudinal experimental data and is a clear priority for future research.

While this type of longitudinal experimental research was beyond the scope of a PhD, an intervention portfolio has been presented in section 5.2 which details what such an intervention aimed at answering these additional research questions could look like. This portfolio aims to satisfy the final component in the 4-component process in health intervention planning and take into considerations the findings presented throughout this thesis. [45, 46] This proposed intervention outlines practical application of findings from survey 1, related to obesogenic eating behaviours within the FFE and further encapsulates key output messages from survey 2, to produce a proposal specific to the interest and needs of Australian parents of young children (section 5.2). Core behaviour change strategies, theories and intervention components, as explored in section 2.4, have also been included to maximise the potential to modify children's eating behaviours. It should be noted, however, that while it is acknowledged that bi-directional relationships between children's eating behaviours, FFE and weight status likely exist, this intervention proposal focuses on parent-driven relationships since parents act as gatekeepers of the FFE and are key agents of change within this relationship.

In addition to application within the proposed intervention, outputs from survey 2 are likely relevant to a broad scope of practitioners with implications for future research and clinical practice. For instance, the high acceptability of technology-based interventions as a medium for engaging parents of young children in behaviour change strategies is an important output that may be used to guide decisions on intervention delivery modes in future research or clinical practices within similar populations. Of similar importance, many parents also indicated that face-to-face intervention platforms still hold appeal as a method of intervention delivery, particularly when used alongside technology-based platforms. This too is likely to be relevant information that can be used to inform future research practices. On this note, while Facebook® is currently a highly popular social media platform, the constant evolution of technology means it is likely that this popularity will be surpassed, and researchers will need to be adaptable in their use of technology for research purposes.

Understanding of key barriers faced by parents in addressing their child feeding concerns is also likely to be useful in informing future research. Parents acknowledged time, affordability, and child behaviour (tantrums), as key barriers in addressing child feeding concerns. These barriers, as likely to be generalisable to many parent populations, should be kept in mind for future intervention planning and strategies. Furthermore, future interventions and clinical practices should acknowledge that while parents appear motivated to address their child feeding concerns, they are likely to be more receptive to messages framed towards addressing child feeding difficulties (e.g. fussy eating), as opposed to weight status directly. Fortunately, responsive feeding practices, authoritative parenting strategies, and the creation of reinforcing FFE's, are expected to be effective in addressing fussy eating as well as the risk of obesity via eating behaviours.

The introduction of the concept of a technology-based intervention champion is also an important output of this thesis that may be used to inform future practices. That is, traditional programs that use intervention champions have been shown to be more effective than those that do not, and as such, parent's willingness to participant as a champion in online interventions holds much promise for future research to maximise observational and peer learning, as crucial to behaviour change in accordance with the SCT. [347, 368] Additional data are needed, however, regarding how to best support and train online intervention champions, including how much and what type of support they require, how long they should be engaged with an intervention, and the most effective way to monitor and evaluate their impact. Implementing the proposed intervention would provide opportunity to pilot the use of champions in an online intervention and gather these desired data. Key areas for future research are summarised in table 42.

Table 42: Key areas for future research
1. Greater understanding of neuro-biological influences on appetite in early childhood is needed. 2. Future attention should be given to the potential of appetite/eating behaviours to predict future obesity, thus supporting use of such measures for early identification of obesity risk and measures of effectiveness of obesity prevention. 3. Priority should be given to determine the feasibility of modifying appetite/eating behaviours, particularly in children who are genetically susceptible to obesity. 4. Longitudinal and prospective studies are needed to disentangle the direction of relationship between eating behaviours, obesity and FFE variables. 5. Further attention to the role of overt verse covert restriction on children's eating behaviours at different age points across childhood is needed. 6. Future research into the feasibility and efficiency of technology-based interventions in driving parent's behaviour change within the FFE is required. 7. Exploration of effectiveness of intervention champions in supporting intervention participation and engagement is needed, as is information into how to best support champions in their role in interventions.

5.1.4 Conclusion

In addressing the major aims of this thesis, significant gaps in the literature were addressed and a comprehensive understanding of the relationship between the FFE and children's eating behaviours and obesity status in early childhood in Australia established. Considering the current childhood obesity climate, these finding have important applications in the public health sector by suggesting that obesity prevention attention extend beyond the current focus on *what* children are fed but to also encompass *how* children are fed within the context of the FFE.

In this regard, the FFE contains a range of variables that are potentially modifiable, particularly parent's feeding strategies and parent's nutrition-related beliefs, that could act as targets for obesity prevention interventions. While additional research is needed, it is likely that effectively modifying these FFE variables will result in positive change in childhood obesity, through the mediating role of eating behaviours, particularly food responsiveness. Shifting obesity prevention attention towards such eating behaviour intermediaries, rather than remaining focused explicitly on weight outcomes, may; 1) improve parent's engagement in intervention protocols; 2) overcome issues of weight stigma in parent and health-care provider dialogue, and; 3) provide an alternative outcome measure for obesity prevention interventions that reduces research burden related to time and in obtaining clinical anthropometric measures.

The identification of modifiable and mediating variables in childhood obesity development, as well as the selection and justification of appropriate theoretical models satisfies the first three components in the four-component process in planning health intervention suggested by Uesugi and colleagues (2016), and, in accordance with the public health nutrition community capacity building stages, adequately defined the need, and satisfied the determinants analysis, in order to further develop the prospect of an early childhood obesity prevention intervention focused on effecting change in children's eating behaviours via modification of the FFE, as presented in section 5.2 below. [45, 46, 50]

5.2 Recommendations for intervention design

This final section draws together the findings presented throughout this thesis to propose an intervention design, as aligning with the final stage of the 4-component process in planning health intervention, as well as the action and assessment stages of capacity building (figure 12). [45, 46, 50] In completing this, concepts of curriculum planning and knowledge acquisition from the education sector, behaviour change concepts from public health, and psychology practices including cognitive behavioural therapy (CBT) principles were drawn upon.

While the research objectives of this intervention were directed towards achieving eating behaviours that are likely to reduce the childhood obesity risk (e.g. reduced food responsiveness and increased satiety responsiveness; section 4.1.3), as parents appear to have greater concerns regarding fussy eating behaviours, low intake of fruit and vegetables, and high intake of discretionary foods (section 4.2.3), core intervention messages were framed towards these parental concerns. This framing was considered appropriate as the use of responsive feeding practices and reinforcing FFE is considered appropriate in addressing both food fussiness and obesogenic eating behaviours (e.g. high food responsiveness and/or low satiety responsiveness).

5.2.1 Intervention overview

This intervention aims to effect change within FFE of Australian children (aged 2.0 – 5.0 years) by modifying parent's behaviours and beliefs (self-efficacy), such that parents implement more responsive feeding practices, are supported in developing food utilisation skills, and are guided in altering underpinning nutrition-related beliefs, as likely to create FFE's that encourage children to appropriately balance food approach and food avoidance eating behaviours such that energy homeostasis can be maintained and the risk of obesity reduced (table 43).

A family-based healthy lifestyle approach was taken in the planning of this intervention protocol, as described in section 2.4.3.1, such that this intervention incorporates knowledge and skills around authoritative parenting and child management. [310, 332] Priority was given to strategies aimed at developing parents understanding of children's eating behaviours, along with core behaviour change techniques such as self-monitoring, goal-setting, problem solving skills, and eating cue control (e.g., structuring the home environment to support healthful eating behaviours). These strategies have been highlighted across the literature and are consistent with principles of cognitive behavioural therapy (CBT), which can be utilised to challenge unhelpful thinking (e.g. beliefs) to support behaviour change. [330, 331, 464, 465] Connections to child physical activity, play opportunities, sleep, and screen time, as relevant to emerging and evolving themes and concepts during the intervention, have been allowed for within the protocol but were not a key focus of the intervention.

5.2.1.1 Primary objective

To determine if, in comparison to a control group of Australian parents with children 2.0 – 5.0 years, children of intervention parents exhibit less obesogenic eating behaviours (e.g. less food responsiveness, more satiety responsiveness, as well as less food fussiness) following a 12-week online intervention and at 2, 3 and 5 years follow up. To further determine if, at 2, 3 and 5 years follow up differences in eating behaviours translate into meaningful differences in child weight status (BMIz and waist circumference; table 43.1).

5.2.1.2 Secondary objective

To determine if, in comparison to the control group of Australian parents with children 2.0 – 5.0 years, intervention parents implement more responsive feeding practices, more authoritative parenting practices, have better nutrition related beliefs, greater self-rated food utilisation skills, and create a more healthful FFE following a 12-week online intervention. Further details of the primary and secondary objectives, and research questions can be seen in table 43.1.

5.2.2 Current situation

This thesis has thoroughly explored the key features of current FFEs of Australian children (2.0 – 5.0 years), as well as the key concerns and perceptions of parents in relation to child feeding. The key features of the current situation are outlined in table 43.2. These features, in conjunction with the findings of the literature reviewed, were used to guide key messages of this intervention. This intervention is unique as it focuses on differences in children’s eating behaviours during early childhood which has not previously been seen. Further to this, utilising technology-based platforms to deliver such an intervention allows for a diversity of participants to be reached, thus overcoming current issues within the literature related to homogenous samples and allows investigation of differences in intervention effectiveness based on the differing demographic and psycho-social variables of participants.

5.2.3 Protocol

This intervention has been planned for delivery via a combination of online platforms (website, email, Facebook®) with the opportunity for face-to-face delivery where geographically possible, and follows an intention-to-treat (ITT) protocol with participants would be randomised to either the intervention or control protocol. Control participants will receive an alternative ‘child safety protocol’ (focused on physical safety of children within the home and first aid). Intervention participants will receive access to a website housing 6 modules (covering 12 topics over 12 weeks, as based on participants preferred intervention duration detailed in Appendix 6), access to a private Facebook® group, and regular emails prompting participation. Where face-to-face delivery is possible, participants will additionally receive 6, fortnightly face-to-face session aligning with the 6 modules presented online. Prior to randomisation participants will be screened for eligibility, based on the inclusion/exclusion criteria defined in table 43.3. Using an ITT protocol will promote internal reliability, while a broad inclusion criterion and the ability for inclusion irrespective of geographical boundaries will promote external validity.

Following screening for eligibility and completion of the baseline survey, participants will be randomised to a group. Participants randomised to the intervention group will have the option to express their interest in being an intervention champion. Depending on numbers of interested participants in the intervention group (after randomisation), potential champions will be recruited and provided preliminary training and additional screening. The final (randomised) selection of champions will be based on final numbers of self-nominating participants that continue to indicate interest following training and screening. In the event that a high number of participants are willing to be intervention champions, options to interchange champions during the intervention will be considered (e.g. champion of the week).

A sample size for this intervention has not yet been calculated, however, given that this intervention will be conducted online, recruitment is not restricted due to geographical boundaries and, as based on previous recruiting experience in online platforms, it is expected that with sufficient recruiting budget, achieving a statistically sufficient sample will be possible. As a guide, the InFANT extend trial, estimated that 270 participants would be needed in the intervention arm (540 participants total), adjusting for noncompliance, multiple comparisons and withdrawal rates, to detect a 4% difference in child BMI (i.e. 0.66kg/m2) and 3% in waist circumference (i.e. 1.5cm). [321] These recruitment estimates seem achievable based on previous recruitment efforts within this thesis.

Given the potential for recruiting a large sample, there is concerns, however, regarding the researcher capacity to effectively facilitate a large online group. Consideration is currently being given to the 'ideal' number of participants for statistical significance in intervention protocol as well as effective facilitation. Options such as delivery of 2 smaller intervention groups (successive 12-week intervention periods) will be considered. Further details about the proposed intervention protocol can be seen in Table 43.3.

5.2.4 Learning outcomes

Table 43.4 details both declarative and procedural knowledge-based learning outcomes for this intervention.

5.2.5. Adoption process

The adoption processes detailed in table 43.5 draws heavily from concepts of curriculum planning and knowledge acquisition from the education sector with integrated application of theoretical frameworks (HBM & SCT) and behaviour change principles (CBT). [331, 336, 346, 348] In particular, the reputable works of Marzano and Pickering (1997) are drawn upon to plan ways to promote participant engagement and knowledge acquisition through embedded opportunities for positive attitudes and perceptions around the intervention to be developed. [466] In table 43.5 consideration was given to opportunities to ensure that participants feel *accepted* by the researcher and peers within the intervention, that a sense of comfort and order can be achieved through layouts, thorough planning and organisation, and that participants perceive the intervention and its' tasks as of value and interest. [466] Additionally, in table 43.5 opportunities were planned for participants and researchers to develop habits of mind that enable creative, critical and self-regulatory thinking to maximise intervention outcomes. These habits of mind particularly encompass and highlight the integration of relevant theoretical frameworks (HBM & SCT) and behaviour change principles (CBT) that are integrated into intervention strategies. [331, 336, 346, 348]

5.2.6 Learning procedure

Table 43.6 details the modules and topics to be covered within the intervention and provides details of alignment to adoption processes and theoretical models, resources, and opportunities for data collection.

5.2.7 Evaluation

The final section of table 43.7 – 43.9 details planned evaluation procedure and opportunities.

Table 43: Intervention strategy portfolio

43.1 Intervention overview

Target population	Duration	Intervention focus	Delivery medium
Australian parents of children 2.0 – 5.0 years of age	12 weeks, with possible extension Follow up 6 months, 12 months, 18 months, 24 months, with possible extension	This intervention aims to effect change within FFE’s of Australian children 2.00 – 5.00 years by modifying parent’s behaviours and beliefs (self-efficacy), such that parents implement more responsive feeding practices, are supported in developing food utilisation skills, and are guided in altering underpinning nutrition related beliefs, to create FFE’s that encourage children to be competent eaters* and, consequently, are at a reduced risk of obesity.	A combination of online platforms only (e.g. website, email, and/or Facebook® group) *Face-to-face delivery options where geographically possible

NOTE:

*Children with ‘healthful eating behaviours’ are able to respond to innate hunger and satiety signals, and appropriately balance homeostatic and hedonic appetite systems such that a healthy weight is maintained, a healthy relationship with food is established, and a positive body image achieved.

Relevant dietary information and recommendations refers to that aligning with the Australian Dietary Guidelines (NHMRC, 2013)

Primary objectives

In comparison to the control group of Australian parents with children 2.00 – 5.00 years, children of intervention parents will exhibit less obesogenic eating behaviours (e.g. less food responsiveness, more satiety responsiveness, and less food fussiness) following a 12-week online intervention and at 2, 3 and 5 years follow up. At 2, 3 and 5 years follow up these differences eating behaviours will translate into meaningful differences in child weight status (BMIz and waist circumference).

Secondary objectives

In comparison to the control group of Australian parents with children 2.00 – 5.00 years, intervention parents will implement more responsive feeding practices, more authoritative parenting, have better nutrition related beliefs, greater self-rated food utilisation skills, and create a more healthful FFE following a 12-week online intervention.

- To collect longitudinal data of children’s and parents eating behaviours during early childhood (from control group).

<u>Primary research questions:</u>

- Is a 12-week online FFE intervention an effective way to change parent’s feeding practices, parent’s food and nutrition related beliefs, parent’s food utilisation self-efficacy, the availability of fruit and vegetables within the home, the use of TV/electronic devices?
- Are these changes in FFE maintained at 6 months, 12 months, 18 months, 2 years follow up, 3 year and 5 year?
- To what extent can an online intervention protocol become self-sustaining (participants continue to engage with the online community/protocol after completion of the intervention with minimal researcher inputs) following establishment during a 12-week intervention? (do participants stay active in the group? How many posts per week/month? Do new members join the group?)
- Can children’s and parents eating behaviours be changed during a 12-weeks online intervention?

- Are changes in children's and parents eating behaviours following a 12-week intervention maintained at 6 months, 12 months, 18 months, 2 years, 3 year and 5 years follow up? - Do changes in FFE and/or children's eating and parents eating behaviours translate into changes in child BMIz or waist circumference (parent reported, child health nurse reported, and/or where possible researcher collected) at follow up intervals (6 months, 12 months, 18 months, 2 years, 3 years and 5 years follow up+)?

43.2 Current situation	
Current family food environment situation (as reported in section 4.1)	**Current motivations of parents (as reported in section 4.2)**
Australian families of children 2.0 - 5.0 years currently: - Participated in 13.5 family meals per week - Used TV/electronic devices during meals in 60% of families, - Generally consider nutrition as important for their family, - Always have fruit and vegetables available in over 90% of families - have reasonable levels of nutrition knowledge (11.1/13; 86% correct) Parents of Australian children: - appear to misunderstand developmentally normal eating behaviours - use inappropriate feeding strategies to encourage consumption beyond hunger and satiety cues - position food as favourable and desirable through non-responsive feeding strategies - transcend their beliefs about healthy eating on to children via the family food environment - may lack food utilisations skills which contributes to poor nutrition related beliefs Parents of Australian children 2.0 – 5.0 years source nutrition information predominately from: - Internet/websites (82%) - Government material (e.g. Australian Dietary Guidelines) (39%) - Family/ friends/kinship group (43%)	Parents are concerned about their children: - Being fussy eating (54%) - Not eating enough fruits and vegetables (47%) - Eating too many discretionary foods (47%) Parents are interested in strategies to: - Support children eat the right type of food (64%) - Reduce fussy eating (60%) - Prepare quick meals (50%) - Create tasty, healthy family meals (49%) - Support children eat the right amount of food (49%) - Create affordable family meals (46%) Parents barriers to making behaviour change include: - Time (59%) - Child tantrums (33%) - Money (29%) - Knowledge about food and nutrition (18%) Enhancing engagement - 24% of parents were willing to participate as intervention champions

43.3 Protocol	
Intention to treat (ITT) **Recruitment:** In addition to an online advertising campaign, childcare centres, community health services, and playgroup services will be approached to assist in recruit participants. <u>Eligibility:</u> Inclusion criteria: Australian resident. Parent/caregiver of a child 2.00 – 5.00 years. Child must reside with parent/caregiver most of the time (e.g. 3 weeks per month). Parent must be over the age of 18 years. Exclusion criteria: Parents will be excluded from participating in the intervention if their child has a medical or behavioural condition that affect their growth, metabolism, development or eating behaviours. **Allocation:** Participants will be randomly assigned to the intervention or control group following completion of the baseline survey using the randomise feature of SPSS. Ineligible participants will be excluded prior to randomisation. **Sample size:** sample size to determine a statistically significant effect has not yet been calculated.	
<u>Intervention protocol</u> Online (e.g. website, email, and/or Facebook® group) intervention protocol - <u>Website:</u> House 6 self-paced modules (each containing 2 topics) including articles, videos, hyperlinks, reflective activities, homework tasks; survey items/data collection tools - <u>Email:</u> Provided weekly to invite participants to complete topics, homework tasks/reflective activities, data collection tools, updates from Facebook®, article snippets with hyperlinks back to website - <u>Private Facebook® group:</u> Act as discussion forum/ interactive hub, links to website, articles/videos, prompt participation, Champions will be selected (from nominating participants), trained and used to	<u>Control protocol</u> 'Child safety protocol' (focused on physical safety of children within the home and first aid). Online (e.g. website, email, and/or Facebook® group) intervention protocol - Website: House 6 self-paced modules (each containing 2 topics) including articles, videos, hyperlinks, reflective activities, homework tasks; survey items/data collection tools - Email: Provided weekly to invite participants to complete topics, homework tasks/reflective activities, data collection tools, updates from Facebook®, article snippets with hyperlinks back to website - Private Facebook® group: Act as discussion forum/ interactive hub, links to website, articles/videos, prompt participation,

assist facilitate discussions, direct to relevant articles/FAQ responses, motivate and engage participants.	

43.4 Learning outcomes/standards:	
Knowledge & understanding: (Declarative) ○ Understanding of developmentally 'normal' eating behaviours, the premise of healthful eating behaviours and the feeding dynamic model ○ Understanding of the differences between responsive and non-responsive feeding practice ○ Understanding of overt restriction and consequences of such practices ○ Understanding of importance access, availability and exposure to healthful foods (link to overt restriction) ○ Understanding of food cues, how they are influenced and the consequence for eating behaviours ○ Understanding of general food and nutrition advice/information (AGHE) ○ Understanding of importance of sleep hygiene (and relationship with screen time, physical activity and play)	Skills: (Procedural) ○ Use of responsive feeding strategies (to support eating right type and amount of food) ○ Use of behaviour management and authoritative parenting techniques ○ Development of food utilisation skills such that beliefs about the ease, convince and taste about healthy food/meals is changed (grocery shopping skills; meal prep/planning skills; quick, healthy, tasty meal solutions) ○ how to identify and source reliable nutrition knowledge ○ Create reinforcing family food environments (stimulus control) ○ Problem solving, decision making, self-monitoring skills
43.5 Adoption processes:	
43.5.1 Attitudes & perceptions **<u>ATTITUDES & PERCEPTIONS:</u>** <u>1. Feel accepted by researcher and peers</u> 1.1 Establish clear rules for engagement and interaction within the Facebook® group – contained within the participant consent and reiterated within the 'about' section of the Facebook® group. Clear protocol for managing misconduct will be detailed and carried out. Settings will be utilised as necessary to 'screen' posts before being displayed within the Facebook® group. 1.2 Researchers will develop skills in CBT and consult with CBT experts to ensure	**43.5.2 Habits of mind to support participant development, engagement & adherence** **<u>4. CREATIVE THINKING</u>** <u>4. 1 Persevere</u> Small sequential steps in declarative and procedural knowledge acquisition - Use of modules to support sequential movement through the intervention and the acquisition of small changes in knowledge, behaviours and practice is used to assist participants persevere and complete the learning tasks, integrate core messages and adopt behaviour change (embedded CBT strategies). <u>4.2 Push the limits of your knowledge and abilities</u>

participants experiences are validated, the researcher is authentic and maintains positive regard. Champions will receive training in these aspects of CBT. 1.3 Researchers and Champions will engage in Facebook® etiquette training to ensure positive interaction and appropriate digital equivalents of positive interactions are achieved. Champions, as members of the participant community, will aid in using appropriate language and dialogue. 1.4 Opportunities will be structured for participants to interact, collaborate, allowing peer learning, observational learning and generate feelings of acceptance within the group. 1.5 Recognise and provide for participants individual differences by using multicultural literature, resources, examples and case studies, modifying probing and leading questions, providing varied structured activities that allow all students opportunities to make valuable contributions and share personal experiences and connect with life experiences (anagogical practice). <u>2. Experience a sense of comfort and order</u> 2.1 Use of synchronous and asynchronous engagement options to allow participants to ‘take breaks’ and engage with the intervention as suitable to their needs. 2.2 Participants will be provided dot points highlighting key learning objectives in each topic and module, checklists and success criteria to check for understanding of content. 2.3 Experts in website design and IT will be used to assist with website development, and video production and editing to ensure a sense of order as participants move through the intervention modules. 2.4 Within the Facebook® group the concept of ‘bracketing’ will be used, where by ‘off topic’ discussion points will be ‘bracketed’ for later discussion. This allows one	Participant self-setting and seeking of challenges through facilitated learning experiences, homework tasks and reflective activities to develop self-efficacy and effect behaviour change (allowing tailored strategies; embedded CBT strategies – goal orientated; behavioural capabilities; reciprocal determinism). <u>4.3 Generate, trust and maintain your own standards</u> Participants will be asked to generate their own standards of evaluation of behaviour change and intervention adoption and set standards to influence others through discussion activities. <u>4.4 Generate new ways of viewing a situation that are outside the boundaries of standard conventions</u> Participants generate new ways to view situations (i.e. effectiveness of feeding strategies, barriers and perceived verse real) through experiential tasks, identification of maladaptive thinking and beliefs (embedded CBT) **<u>5. SELF-REGULATED THINKING</u>** <u>5.1 Monitor your own thinking:</u> Triggers will be used to prompt participants to monitor their own thoughts and behaviours (reiterating new ways to view situations; SCT reinforcement; embedded CBT) <u>5.2 Plan appropriately</u> Appropriate planning of core intervention messages through synchronous and asynchronous opportunities - Effective facilitation of an online environment, particularly the dynamic virtual environment of Facebook® is planned through: - A planned, sequential curriculum housed on a comprehensive website containing written articles, videos, interactive tracking and planning tools, reflective activities, homework tasks, and data collection tools - Pre-empted Facebook® discussion topics related to each module and topic - Scheduling of Facebook® posts and email campaigns introducing modules, topics,

topic/issue to be addressed per discussion. This is particularly important in for participants engaging asynchronously in terms of being able to 'find' desired content. <u>3. Perceived Tasks as Valuable and Interesting</u> 3.1 Learning experiences, homework tasks, reflective activities, and discussion topics will focus on being relevant, of valuable and interesting to engage participants and establish a sense of academic/professional trust. 3.2 Constructs of the HBM (perceived barriers, self-efficacy, concerns for appearance/social desirability, future consequences, perceived importance) will be used to guide relevance, interest and engaging learning experiences. Including a preferential focus on parents identified perceived concerns and severity (e.g. fussy eating), rather than the researchers agender (e.g. childhood obesity, food cue responsiveness). 3.3 Activities and learning experiences within the intervention will allow for participants to tailor aspects of their program to their own needs and goals through embedded opportunity for connectivism and self-directed learning. 3.4 A variety of delivery modes (website, email, Facebook® group) and learning experiences (asynchronous and synchronous activities and engagement opportunities; written content, videos, homework tasks, reflective activities, and discussion topics) will be used to cater to a diversity of participant preferences and create interest in the program. 3.5 Champions used to model responses, including responses to feedback, setbacks, challenges, self-evaluation to allow for peer and observational learning (SCT).	and data collection (enrolment of control 'wait' groups) - Planned discussion starters and 'click bait' posts to allow researcher and participants to develop rapport and boost engagement/post reach (maximising Facebook® algorithms) - Pre-develop 'champion' selection process and development curriculum/modules (Toolkit) Participants will be encouraged to plan appropriately for change through use of resources such as shopping lists, meal planning, time planning and goal setting tools <u>5.3 Identify and use necessary resources</u> Researcher will identify, development and utilise necessary human and non-human resources including expert contributions in the form of articles, videos, downloadable resources (worksheets) consultation on development (i.e. psychologists, IT support/editing). Participants will be guided through identification of their own available human and non-human resources at an intra- and inter- personal level (e.g. family support, time, finances, personal skills) as well as community and organisation level (Facebook® support group, local support services, farmers markers for cheaper produce etc. – self efficacy) <u>5.4 Respond appropriately to feedback</u> A piloting phase will allow researchers to respond appropriately to participant feedback and program modification accordingly. Consultation with experts will allow feedback and program modification accordingly. Participants will be encouraged to seek feedback on homework tasks through Facebook® groups participation and guided on how to respond to this appropriately through Champion modelled responses.

	<u>5.5 Evaluate the effectiveness of your actions</u> Participants will be encouraged to participate in self-reflection activities to evaluate their own actions. Champions will be used to model such self-evaluation processes through Facebook® group discussion. **Effectiveness of researcher actions (process evaluation) will be conducted qualitatively and quantitatively throughout the program implementation (see section 6.3.7 for formal evaluation plan) **<u>6. CRITICAL THINKING</u>** <u>6.1 Be accurate and seek accuracy</u> The researcher will ensure the accuracy of the information and resources used throughout the intervention, as based on up-to-date evidence and national recommendation as appropriate. The researcher will collaborate with appropriate experts, as relevant to the development, implementation and evaluation of the intervention (particularly psychologist experiences in implementation of cognitive behavioural therapy) Participants will be explicitly taught how to seek accurate information and resources in child feeding and nutrition to promote self-efficacy. <u>6.2 Be clear and seek clarity</u> The use of technology may introduce issues around communication for both researchers and participants. Researchers and Champions will avoid using jargon, colloquialisms or expressions that would typically require in person contact to interpret (e.g. facial expressions, tone, body language). Researchers and Champions will be asked to seek clarity when responding to questions from participants in Facebook® groups. Likewise, participants will be encouraged to ask

	questions and maintain open communication with researchers, to seek clarity. <u>6.3 Maintain and Open mind</u> Researchers and Champions will be open, respectful and accepting of a diversity of opinions, perspectives and practices around social, cultural and religious food/ nutrition beliefs and practices to enhance communication of participants with diverse background. As adult learners, participants will be encouraged to draw on prior knowledge and life experiences to contextualise learning experiences. <u>6.4 Restrain impulsivity</u> Researchers will be encouraged to take time to respond appropriately, concisely and clearly to participant questions. Where possible responses to questions will re-direct participants to relevant module content or the FAQ page of the website, where a pre-developed response has been provided. The FAQ page will be a living document and regularly managed and updated as common questions emerge. Settings will be used to monitor Champions responses to questions in the Facebook® group such that they will require researcher approval before being posted. Champions will also be asked to refer participants to the course modules and FAQ page to answer questions as relevant. <u>6.5 Respond appropriately to others' feelings and level of knowledge</u> Researchers and Champions will be vigilant in assessing and monitoring the implicit and explicit messages (comments, questions, discussion points) that reflect participants feelings. Where this assessment and monitoring indicates participants feelings and emotions require additional support/monitoring, participants will be provided with appropriate professional resources. Where participants feelings may be of detriment to other participants, researchers, Champions or the cohesion and progress of the group, the participant will be reminded to the rules of engagement in the program and offending comments/questions,

	deleted. Screening setting will be put in place as necessary and additional actions taken as necessary should detrimental impacts continue.

43.6 Learning procedure				
43.6.1: Module/ Topic	**43.6.2: Learning procedures (module/ topic content and core messages)**	**43.6.3: Links to adoption processes & theoretical models (HBM, SCT) & CBT**	**43.6.4: Resources**	**43.6.5: Data collection tools**
Preliminary tasks	- Collaboration and consultation with experts - Researcher training in CBT - Intervention development - Web design, video development - Data collection tool development	**1.2** Relevant professional development (CBT) **2.3** Comfort & order **4. 1** Persevere **5.2** Plan appropriately **5.4** Respond appropriately to feedback **6.1** Be accurate and seek accuracy	Website Platform Data Collection Platform (Checkbox®) Video Production Facilities Experts/professionals	- Qualitative data
Pilot	- Convenience sample used to pilot website modules (including videos) and data collection tools (online survey's)	**5.2** Plan appropriately **5.3** Identify and use necessary resources **5.4** Respond appropriately to feedback	Website Checkbox® Champion Toolkit Zoom® (focus group)	- Pilot data collection tools (online survey; quantitative – focus group) - Qualitative data
Pre-allocation	**Completion of participant recruitment:** screen sample eligibility based on inclusion/exclusion criteria. **Allocation:** randomise sample using SPSS and allocate an intervention and control group. **Commence champion screening and training:** - Information webinar with interested intervention participants (intervention objectives, aims, methods, role of champions, expectations, requirements, additional training) - Interested champions enrol in training module and	**1.1** Establish clear rules **1.2** CBT basic training **1.3** Researchers and champions will engage in Facebook® etiquette training **2.4** Bracketing **3.5** Champions used to model responses, **5.2** Plan appropriately **6.2** Be clear and seek clarity **6.3** Maintain and Open mind **6.4** Restrain impulsivity	Website Checkbox® SPSS Zoom® (webinar) Champion Toolkit	**Pre-survey administering** - Screen for eligibility (pre- group allocation) - Compare group baseline data Champion training log (*n* sample) Champion applicant questionnaire

	applicant questionnaire - Provide retained champions a downloadable toolkit	**6.5** Respond appropriately to others' feelings and level of knowledge		
Module 1 Introduction phase	**Topic 1: Welcome** ▪ Intro/overview (set agenda for intervention and rational for doing so) ▪ Establish rules and expectations ▪ Get to know you – interactive activity (Facebook® group) ▪ Why are you here? (self-assessment – mood check; how do you feel about…) ▪ What do you hope to get out of the intervention? (self-identifying concerns/problems) ▪ Homework – explore determinants of concerns/problems (self-identify; scheduled *hot* triggers via Facebook® group prompting reflection; Champions model responses via Facebook®)	**1.** Feel accepted by researcher and peers (SCT) **1.1** Establish clear rules **3.1** Relevant tasks **3.2** Concerns/Severity (HBM) **3.3** Tailored strategies **5.1** Monitor your own thinking (Triggers; SCT) **5.5** Evaluate the effectiveness of your actions **6.2** Be clear and seek clarity **6.3** Maintain and open mind	Website Facebook® group Email campaign (e.g. Mailchimp)	- Participant login monitoring - Module completion (page views) - Website checkboxes (feedback, satisfaction) - Facebook® group activity (Likes, reactions, comments, participant posts)
Knowledge acquisition &	**Topic 2: 'What's all the *fuss* about?' - Understanding eating behaviours** ▪ What are eating behaviours, why are they important & how are they influenced? (Explicit learning – website content) ▪ Fussy eating / feeding difficulties 'normal' developmental phase; what's not normal, when to get clinical help (Explicit learning – website content; guest post/video SOS feeding specialists) ▪ Facebook® group Q&A session with SOS feeding specialist/occupational therapist (Champions prepare questions if needed, 'Bracketing') ▪ Why do our children's eating behaviours concern us?	**1.3** Facebook® etiquette **1.4** Collaborative and observational learning **1.5** Engage participant life experiences (diversity) **2.1** Use of synchronous and asynchronous engagement **2.4** Bracketing **3.1** Relevant tasks **3.2** Concerns/Severity (HBM) **3.3** Tailored strategies **4.4** New ways of viewing a situation **5.2** Plan appropriately	Website Facebook® group Email campaign (e.g. Mailchimp) Expert: SOS feeding specialist/ OT	

integration	(self-reflection activity; motivation determinants; reinforcements) -Link to homework responses (Champions model responses via Facebook® group) ▪ Homework - Determine personal severity, importance, perceived benefits in addressing child feeding concerns – reflective/ self-evaluation activity & checklist; preliminary goal setting	**5.3** Identify and use necessary resources **5.5** Evaluate the effectiveness of your actions (CBT) **6.1** Be accurate and seek accuracy **6.2** Be clear and seek clarity **6.4** Restrain impulsivity		
Module 2 Knowledge acquisition & integration Extending & refining	**Topic 3: 'Getting the balance right' – What should children be eating?** ▪ What should children be eating (Australian Guide to Healthy Eating, current recommended intake; Explicit learning – website content; link to eat for health – connectivism) ▪ Reflective activity (online FFQ) – interactive tool comparing child's intake to recommended; where does my child's diet need to improve? ▪ The relationship between eating behaviours and dietary intake; To change dietary intake, we need to change eating behaviours (e.g. reduce fussy eating) (Explicit learning – website content) ▪ Reflect on Topic 2 Homework – reflect on the severity, importance, perceived benefits -has it changed since FFQ results? (Leading questions via website; follow up discussion via Facebook® group; Champions model responses via Facebook®) ▪ Barriers to achieving AGHE (taste, convenience, expense; child tantrums, family support; Explicit learning – website content) ▪ Homework – identify personal barriers in addressing	**1.3** Facebook® etiquette **1.4** Collaborative and observational learning **2.1** Use of synchronous and asynchronous engagement **2.4** Bracketing **3.1** Relevant tasks **3.2** Concerns/Severity (HBM) **3.3** Tailored strategies **4.2** Push the limits of your knowledge and abilities (Behavioural capabilities; reciprocal determinism) **4.4** New ways of viewing a situation **5.1** Monitor your own thinking **5.2** Plan appropriately **5.4** Respond appropriately to feedback **5.5** Evaluate the effectiveness of your actions (CBT) **6.1** Be accurate and seek accuracy **6.2** Be clear and seek clarity **6.4** Restrain impulsivity	Website Facebook® group Email campaign (e.g. Mailchimp) FFQ	- Participant login monitoring - Module completion (page views) - Website checkboxes (feedback, satisfaction) - Facebook® group activity (Likes, reactions, comments, participant posts) - Food frequency questionnaire (FFQ)

	child feeding concerns; determining if barriers are perceived or real (self-identify; monitoring thinking; scheduled hot triggers via Facebook® group prompting reflection; Champions model responses via Facebook®) **Topic 4: 'Kicking Goals' – Goal setting and behaviour change** ▪ Reflect on homework – e.g. What resources do you identify? What barriers did you identify to address these concerns? Are these barriers real or perceived? – How do you know? ▪ Cognitive models of behaviour change; Challenging thinking/beliefs – monitoring thinking (explicit learning – website content) ▪ Facebook® group Q&A with psychologist – behaviour change/ CBT; Champions prepare questions if needed, 'Bracketing') ▪ Set SMART goal (Explicit learning – website content; Champions model SMART goal via Facebook®) ▪ Homework - What knowledge and skills do you need to achieve your goal?	**1.3** Facebook® etiquette **1.4** Collaborative and observational learning **2.1** Use of synchronous and asynchronous engagement **2.4** Bracketing **3.1** Relevant Tasks **3.2** Concerns/Severity (HBM) **3.3** Tailored Strategies **4.2** Push the limits of your knowledge and abilities (Behavioural capabilities; reciprocal determinism) **4.4** New ways of viewing a situation **5.1** Monitor your own thinking **5.2** Plan appropriately **6.1** Be accurate and seek accuracy **6.2** Be clear and seek clarity	Website Facebook® group Email Campaign (e.g. Mailchimp) Expert: psychologist/CBT	
Extending & refining				

Module 3 Knowledge acquisition & integration Extending & refining	**Topic 5: 'Let's get dynamic #1' - The Dynamic Feeding Model [467]** ▪ What are healthful eating behaviours? – how do they relate to diet quality and quantity (Explicit learning – website content) ▪ The dynamic feeding model - How can it help you achieve your goal (Explicit learning – website content) ▪ Division of responsibility ([DOR] Explicit learning – via website content) [467] ▪ Authoritative parenting techniques & practical exercises (Explicit learning – via website content; external links – getting extra help; connectivism – tailored strategies) ▪ Responsive feeding V non-responsive feeding (Explicit learning – via website content) ▪ Distinction between overt V covert restriction (Explicit learning – via website content) ▪ Quiz – identify between responsive & non-responsive feeding, between overt & covert restriction (website) ▪ Homework: Analysing errors – reflecting and analysing implementation of DOR/ authoritative parenting in the past/presently	 **1.3** Facebook® etiquette **1.4** Collaborative and observational learning **2.1** Use of synchronous and asynchronous engagement **3.1** Relevant tasks **3.3** Tailored strategies **4.2** Push the limits of your knowledge and abilities (Behavioural capabilities; reciprocal determinism) **4.4** New ways of viewing a situation **5.1** Monitor your own thinking	 Website Facebook® group Email Campaign (e.g. Mailchimp) *Expert: parenting/child behaviour as necessary	 - Participant login monitoring - Module completion (page views) - Website checkboxes (feedback, satisfaction) - Facebook® group activity (Likes, reactions, comments, participant posts) - Quiz results - Pantry audit
	Topic 6: 'Let's get dynamic #2' - Implementation of Dynamic feeding & DOR [467] ▪ Connecting errors in DOR/dynamic feeding (from homework) to barriers (real & perceived) – monitoring thinking; CBT (explicit learning – website content)	 **1.3** Facebook® etiquette **1.4** Collaborative and observational learning **2.1** Use of synchronous and asynchronous engagement **2.4** Bracketing	 Website Facebook® group Email campaign (e.g. Mailchimp) Pantry audit tool	

Using knowledge meaningfully	▪ Challenging thinking/beliefs around child feeding–monitoring thinking and learning to trust your child's hunger and satiety (explicit learning – website content) How do we 'do' DOR (explicit learning – website content; Champions model examples, problems/discussion via Facebook®) – observational learning, peer learning: - Setting up single family meals, structured meal timing/setting and overcoming barriers - Removing pressure, bribes, rewards, coercion - Creating a 'safe' meal environment including safe foods and how to integrate them into a family meal - Implementing covert restriction – reducing availability of discretionary foods and increasing access, exposure and availability of 'green' (core) foods ▪ Problem solving Activity – take small steps towards DOR, dynamic feeding and individual SMART goal, linking to previous homework [analysing errors, identifying barriers & resources – planning for incremental change] (via Facebook® group prompting discussion; Champions model responses via Facebook®; example incremental changes on website) ▪ Green snack options – connectivism, peer learning (Facebook® group discussion) ▪ Homework - Covert restriction challenge (increasing the proportion of 'green' foods (e.g. removing discretionary foods – pantry audit)	**3.1** Relevant Tasks **3.2** Concerns/Severity (HBM) **3.3** Tailored strategies **4.2** Push the limits of your knowledge and abilities (Behavioural capabilities; reciprocal determinism) **4.4** New ways of viewing a situation **5.1** Monitor your own thinking **5.2** Plan appropriately **6.1** Be accurate and seek accuracy **6.2** Be clear and seek clarity	(excel spreadsheet)	

Module 4: Using knowledge meaningfully	**Topic 7: Understanding your food environment** ▪ Reflect on implementation of DOR, dynamic feeding and covert restriction from Module 3 homework – what has been difficult? What has been easy? What do you need more help or information on? How are you progressing with your SMART goal? (via Facebook® group prompting discussion; Champions model responses via Facebook®) ▪ Cognitive models of behaviour change; Challenging thinking/beliefs – monitoring thinking to persist with change/overcome barriers (explicit learning – website content) ▪ Reinforcing DOR/Dynamic feeding model with FFE change (explicit learning – website content; Champions model examples, problems/discussion via Facebook®) - Importance of access, availability and exposure in changing eating behaviours and accepting healthy foods - Other reinforcing factors – TV, sleep, active play - Value of parent and peer role modelling - Parent's self-talk and internal dialogues (form of role modelling) - Parent's eating behaviours – monitoring thinking (understanding own eating; emotional eating, eating triggers) ▪ Homework problem solving – identifying and removing food cues, pre-planning alternatives to cues (e.g. using a calming activity [for parent and child] prior to dinner instead of TV; culturally	**1.3** Facebook® etiquette **1.4** Collaborative and observational learning **2.1** Use of synchronous and asynchronous engagement **3.1** Relevant tasks **3.2** Concerns/Severity (HBM) **3.3** Tailored strategies **4.2** Push the limits of your knowledge and abilities (Behavioural Capabilities; reciprocal determinism) **4.4** New ways of viewing a situation **5.1** Monitor your own thinking **5.2** Plan appropriately **6.1** Be accurate and seek accuracy **6.2** Be clear and seek clarity	Website Facebook® group Email campaign (e.g. Mailchimp)	- Participant login monitoring - Module completion (page views) - Website checkboxes (feedback, satisfaction) - Facebook® group activity (Likes, reactions, comments, participant posts)

Using knowledge meaningfully	diverse/sensitive examples provided on website) **Topic 8: 'Making a meal of it' - Food utilisation / Meal planning & prep** ▪ Making healthy meal choices – link back to AGHE, - quick meal ideas - cheap meals/ budget ingredients, how to use them and where to find them – cheap! - adding flavour and health ▪ Label reading, using the HSR, ▪ Avoiding other food cue triggers (e.g. impulse buys/confectionary free checkouts) ▪ Decision making – meal planning, grocery shopping, reducing waste, making meals go further, leftovers, value for money ▪ Triggers – what's for dinner tonight? What have you prepped for tomorrow? Share your dinner/lunch/breakfast inspirations ▪ Homework – Share meal prep and planning inspiration photos/posts via Facebook® group.	**1.3** Facebook® etiquette **1.4** Collaborative and observational learning **1.5** Engage participant life experiences (diversity) **2.1** Use of synchronous and asynchronous engagement **2.4** Bracketing **3.1** Relevant tasks **3.2** Concerns/Severity (HBM) **3.3** Tailored strategies **4.4** New ways of viewing a situation **5.2** Plan appropriately **5.3** Identify and use necessary resources **5.5** Evaluate the effectiveness of your actions (CBT) **6.1** Be accurate and seek accuracy **6.2** Be clear and seek clarity **6.4** Restrain impulsivity	Website Facebook® group Email campaign (e.g. Mailchimp)	
Module 5: Knowledge consolidation phase	**Topic 9: 'I think I can…' - Dealing with setbacks** ▪ Dealing with setbacks (Cognitive models of behaviour change; Challenging thinking/beliefs – monitoring thinking (explicit learning – website content) ▪ What am I still struggling with – Exploring underpinning problems and self-sabotage (beliefs/self-efficacy, child tantrums or behaviour, getting spouse support; website content; Champions model examples, problems/discussion via Facebook®)	**1.3** Facebook® etiquette **1.4** Collaborative and observational learning **1.5** Engage participant life experiences (diversity) **2.1** Use of synchronous and asynchronous engagement **2.4** Bracketing **3.1** Relevant tasks	Website Facebook® group Email campaign (e.g. Mailchimp)	- Participant login monitoring - Module completion (page views) - Website checkboxes (feedback, satisfaction) - Facebook® group activity (Likes,

	▪ mapping tools and prompts – have I created a family food environment that enables my children to be a competent eater? (explicit learning – website content, interactive tools) ▪ Homework: Widening your food environment – do my friends/family reinforce the DOR? Does my playgroup, childcare, mothers group reinforce DOR? (explicit learning – website content; multicultural/ socio-demographic case studies; Facebook® discussion; Champions model	**3.2** Concerns/Severity (HBM) **3.3** Tailored Strategies **4.4** New ways of viewing a situation **5.2** Plan appropriately **5.3** Identify and use necessary resources **5.5** Evaluate the effectiveness of your actions (CBT) **6.1** Be accurate and seek accuracy **6.2** Be clear and seek clarity **6.4** Restrain impulsivity		reactions, comments, participant posts) - Family food environment mapping tool
	Topic 10: Continued learning & reliable nutrition information ▪ Strategies to support ongoing learning and implementation of intervention strategies and practices (explicit learning – website content) ▪ Connectivism activity – participants source unfamiliar nutrition information and aim to determine its validity, reliability and practicality through guided critical analysis (e.g. is it too good to be true? does it contradict other reputable dietary info [e.g. AGHE – avoid restrictive diets, elimination of food groups, excessive restriction – remember DOR/dynamic feeding], could it harm me/my family? Are there elements that could be practical/useful [e.g. increasing fruit and vegetables], who said it? Can they be trusted/what is their agenda? (Share on Facebook® group; Champions initiate sharing and discussion)	**1.3** Facebook® etiquette **1.4** Collaborative and observational learning **2.1** Use of synchronous and asynchronous engagement **2.4** Bracketing **3.1** Relevant tasks **3.2** Concerns/Severity (HBM) **3.3** Tailored strategies **4.2** Push the limits of your knowledge and abilities (Behavioural capabilities; reciprocal determinism) **4.4** New ways of viewing a situation **5.1** Monitor your own thinking **5.2** Plan appropriately **6.1** Be accurate and seek accuracy **6.2** Be clear and seek clarity	Website Facebook® group Email campaign (e.g. Mailchimp)	

	▪ How to get the answers you want – who to speak with (e.g. GP's, child health nurses, paediatricians, dietitians, occupational therapist), what questions to ask and how to ask them (explicit learning – website content)			
Module 6: Knowledge consolidation phase	**Topic 11: Course summary (learning consolidation)** ▪ Summarise and reiterate core intervention messages (explicit learning – website content) ▪ - Healthful eating behaviours and the AGHE (Repeat FFQ, compare to previous & AGHE) - DOR and dynamic feeding - Reinforcing food environments (Repeat pantry audit, compare to previous and reflective activity) - Meal planning/food utilisation - Behaviour change theory ▪ Exploring progression towards SMART goal (prompts and lead questions provided on website; Discussion facilitated on Facebook®; Champions contribute to discussion) **Topic 12: Plan for maintaining change** ▪ Cognitive models for maintaining behaviour change; Challenging thinking/beliefs – monitoring thinking (explicit learning – website content) ▪ Facebook® group Q&A with psychologist – maintaining behaviour change/ CBT; Champions prepare questions if needed, 'Bracketing')	**1.3** Facebook® etiquette **1.4** Collaborative and observational learning **2.1** Use of synchronous and asynchronous engagement **2.4** Bracketing **3.1** Relevant tasks **3.2** Concerns/Severity (HBM) **3.3** Tailored strategies **4.2** Push the limits of your knowledge and abilities (Behavioural capabilities; reciprocal determinism) **4.4** New ways of viewing a situation **5.1** Monitor your own thinking **5.2** Plan appropriately **6.1** Be accurate and seek accuracy **6.2** Be clear and seek clarity **1.3** Facebook® etiquette **1.4** Collaborative and observational learning **2.1** Use of synchronous and asynchronous engagement **3.1** Relevant tasks **3.3** Tailored strategies	Website Facebook® group Email Campaign (e.g. Mailchimp) Repeat FFQ Repeat pantry audit Website Facebook® group Email campaign (e.g. Mailchimp) Expert: psychologist/CBT	- Participant login monitoring - Module completion (page views) - Website checkboxes (feedback, satisfaction) - Facebook® group activity (Likes, reactions, comments, participant posts) -Participant satisfaction qualitative data (Facebook® discussion) **– Post-survey administering (intervention & control group)**

	▪ Champions will facilitate Facebook® discussion around participant satisfaction	**4.2** Push the limits of your knowledge and abilities (Behavioural capabilities; reciprocal determinism) **4.4** New ways of viewing a situation **5.1** Monitor your own thinking		
<u>Refresher Course 1 - 4</u> (email invitation at 6 weeks, 12 weeks,18 weeks post, 24 weeks post)	▪ Re-engage participants with intervention core messages and behaviour change strategies (explicit learning via website) ▪ Provide hyperlinks to intervention and relevant external content (tailored intervention – connectivism) ▪ Invite participants to continue to engage with Facebook® group; use leading and discussion questions to prompt engagement, ask participants to share their child feeding journey (Champions encouraged to facilitate discussion)	**1.3** Facebook® etiquette **1.4** Collaborative and observational learning **2.1** Use of synchronous and asynchronous engagement **3.1** Relevant tasks **3.3** Tailored strategies **4.2** Push the limits of your knowledge and abilities (Behavioural capabilities; reciprocal determinism) **4.4** New ways of viewing a situation **5.1** Monitor your own thinking	Website Facebook® group Email campaign (e.g. Mailchimp)	- Participant login monitoring - Module completion (page views) - Website checkboxes (feedback, satisfaction) - Facebook® group activity (Likes, reactions, comments, participant posts)

43.7 Impact evaluation
Via website login monitoring, Facebook® engagements [likes, posts, comments], interactive website tool (e.g. FFQ). 1. Did intervention participants remain engaged with the intervention protocol for the duration of the intervention email opens? 2. Did intervention participants complete all modules? 3. Did intervention participants complete reflective activities? 4. Did intervention participants find the Facebook® group helpful, useful, convenient? 5. Did intervention participants feel the Facebook® group replicate a face-to-face group environment (e.g. did they build rapport with researchers and other participants)? 6. Were intervention champions effective in engaging participants? 7. Did intervention champions *enjoy* their involvement with the intervention? 8. Were intervention champions more engaged with the intervention protocol? 9. Were there significant changes in child diet during the intervention (FFQ)? 10. Were there changes in the proportion of 'green' items in the pantry during the intervention?

43.8 Impact evaluation
Post intervention: *Via pre- post survey.* In comparison to the control group of Australian parents with children 2.00 – 5.00 years, do intervention parents: 1. implement more responsive feeding practices, 2. have more positive nutrition related beliefs, 3. greater self-rated food utilisation skills, 4. create a more healthful FFE (including reduced screen time, increased availability of fruit and vegetables) 5. role model more healthful eating behaviours In comparison to the control group of Australian parents with children 2.00 – 5.00 years, do children of intervention children: 1. exhibit more ‘competent’ eating behaviours (lower food responsiveness, lower food fussiness, higher satiety responsiveness) 2. have lower BMIz and weight circumference (parent reported, child health nurse reported, and/or where possible researcher collected)
43.9 Outcome evaluation
At follow up: *via pre- post survey and website login, email opens and Facebook® group monitoring.* 1. Are intervention effects sustained? 2. Do differences in eating behaviours translated into meaningful differences in child weight status (BMIz and waist circumference; parent reported, child health nurse reported, and/or where possible researcher collected)? 3. To what extent can an online intervention protocol become self-sustaining? - Do participants stay active in the group? - Do Champions stay active in the group? - How many posts per week/month? - Do new members join the group? - Did participants complete the refresher courses?

6. Conclusion

This thesis has provided a comprehensive *picture* of the FFE's Australian children are exposed to during early childhood and the contribution that variables within these environments (individually and collectively) have on childhood obesity status. While the FFE's of Australian children in the sample obtained can generally be considered conducive with positive health behaviours, clear differences in FFE's were seen to relate to variations in children's eating behaviours and obesity status. Furthermore, differences in eating behaviours were seen based on psycho-social and demographic factors which may assist to explain differing rates of obesity among sub-population groups. Recognising and understanding differences in FFE's and the influence these differences have on children's eating behaviours, provides valuable information from which childhood obesity, as an issue of major public health concern, can be addressed.

Parent's use of non-responsive feeding strategies, poor nutrition related beliefs, and insufficient food utilisation skills were prominent factors within the FFE that related to obesogenic eating behaviours in children. Consequently, future obesity prevention initiatives that target these variables are likely to be beneficial in supporting healthful behaviours that reduce the obesity risk. The presence of a mediator relationship between child food responsiveness, parent's use of overt restriction and child BMIz within the works of this thesis, specifically support the perspective that targeting children's eating behaviours is a suitable avenue through which obesity risk can be addressed.

While additional works are needed to articulate changes in eating behaviours that will be of benefit in reducing obesity risk, there is support that children's eating behaviours may provide a suitable surrogate endpoint for childhood obesity prevention interventions that will assist to overcome research burdens particularly in relation to the implementation duration necessary to achieve a meaningful change in child weight. Furthermore, shifting obesity prevention attention towards eating behaviour, as obesity intermediaries, is likely to overcome issues related to weight stigma which may interfere with parent and health-care provider dialogue, while also improving parent's engagement with interventions. This potential for improved parent engagement is supported by the works within this thesis which showed parent's prominent concern for *fussy eating* as opposed to weight-based concerns. In this regard, parents indicated high acceptability towards future participation in an early childhood feeding intervention, particularly if delivered through a combination of online platforms. Such online platforms hold much promise for future intervention delivery, particularly as a means to readily engage a large, geographically diverse sample. Parents specifications and preferences for participation in online interventions have further been detailed within this thesis, as a valuable contribution of these works that can be used to inform future public health practices.

In addressing the major aims of this thesis, a significant gap in the literature has been addressed and a comprehensive understanding of the role of the FFE in relations to children's eating behaviours and obesity status in early childhood in Australia has been established. Considering the current childhood obesity climate, these finding have important applications in the public health sector by suggesting that obesity prevention attention extend beyond the current focus on *what* children are fed but to also encompass *how* children are fed within the context of the FFE. In directing such public health efforts, the potential opportunities of technology should be embraced.

7. References

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Appendix 1: Characteristics of studies on dietary patterns & weight status

Reference	Dietary pattern method	Diet assessment method	Participants (no., age, location)	Outcome focus	Findings	Summary
Ambrosini, GL. (2014) [33]	Review: 5 studies applied PCA or FA and 2 applied RRR to identify dietary patterns	FFQ (4), 48 hr recall (1), 3 x FR (2)	7 studies 3 – 39 years Australia, US, Norway, UK, Finland	Systematically review empirical evidence related to dietary patterns in childhood and later obesity risk	4/7 studies + BMI/adiposity 3/7 null	Comparable obesity promoting DP were identified in all studies consisting of: high consumption of energy-dense, high-fat and low-fibre foods
Leventakou, V. (2016) [468]	PCA	FFQ	n= 1081 4 years Greece	DP associated with SES and lifestyle characteristics	-BMI	3 DP (Mediterranean; Snacky; Western; eigenvalues were 3.72, 1.48 and 1.21, respectively) explaining 45.79% of total variance.
Bell, LK (2013) [435]	PCA	1 x 24-h recall and 2 x 24-h record	n=552, 14 months n= 493, 24 months Australia	Socio-demographic characteristics & adiposity	- BMI	2 DP at each age; ‘14 month core’ (fruit, grains, vegetables, cheese and nuts/seeds); ‘Basic combination’ (white bread, milk, spreads, juice and ice-cream); ‘24-month core foods’ (fruit, vegetables, dairy, nuts/seeds, meat and water); ‘Non-core foods’ (white bread, spreads, sweetened beverages, snacks, chocolate, processed meat).
McNaughton, et. al, (2008) [24]	PCA	FFQ	n=764 12-18 years Australia	BMI Nutrient intakes	- BMI	‘fruit, salad, cereals, fish pattern’ – 11% of variance in diet ‘high fat and sugar pattern’ -5.9% of variance in diet ‘vegetables pattern’ - 3.9% f variance in diet

Perry, et al. (2015) [25]	Multinomial logistic regression	FFQ	n=8,568 9 years Ireland	BMI (normal, overweight, obese)	+ Obese BMI -overweight	Obesity rates across quintiles (Q) (highest diet quality to lowest) Q1: 4.2%; Q2: 5.8% Q3: 7.1% Q4: 6.4% Q5: 8.8% Q5 increased odds of obesity by 56% compared to Q1
Cheng, et. al, (2010) [30]	Dietary indices (NQI & RC-DQI)	3 x FR	n=222 7.4 years Germany	BMI	-BMI z-score - % overweight	Low NQI score – -0.2 BMI z-score (11.6% overweight) Medium NQI score – 0.2 BMI z-score (18.8% overweight) High NQI score – 0.3 BMI z-score (11.8% overweight) P=0.2 (P=0.3) Low RC-DQI – -0.2 BMI z-score (11.7% overweight) Med. RC-DQI – 0.3 BMI z-score (13.6% overweight) High RC-DQI – 0.1 BMI z-score (18.6% overweight) P=0.5 (P=0.01)
Berz, et. a., 2011 [29]	Dietary indices	3 x FR	n=2,327 9-10 years US	BMI over 10 years	+BMI	Over 10 year follow up; changes in mean BMI (Quintile 1 lowest quality): Q1 - 6.6 Q2 – 5.9 Q3 – 5.9 Q4 – 6.3 Q5 – 5.3 BMI at follow up Q1 -26.3; Q5 – 24.4 1.9kg/m^2 lower BMI between Q1 –Q5 at follow up
Hurley, et. al (2009) [31]	Pearson correlations	FFQ	n=317 11 - 16 years US	BMI, Adiposity (DXA)	-BMI + Adiposity	Higher % body/abdominal fat was associated with lower HEI scores ($r = -0.17$ to -0.19; $P < 0.05$)
Zhang, et al (2015) [26]	Factor analysis	3x 24hr Recall	n= 1282 7 – 17 years China	BMI	+BMI	3 dietary patterns explained 27·6 % of the variance in total food intake
Johnson, et al (2008) [27]	RRR	3 x FR	n=521, 5 & 9 years n=682, 7 & 9 years UK	Adiposity (DXA)	+ Adiposity	1 SD increase in pattern score at 7 years was associated with an extra 0.28 kg (95% CI: 0.05, 0.53 kg) of fat mass at 9 year

Ambrosini, et al (2012) [28]	RRR	3x FR	n=6772 7, 10 and 13 years UK	Adiposity (DXA)	+Adiposity	1 SD increase in dietary pattern z-score, increased odds of being in the highest quintile for fat mass by 13% (95% CI, 1–27%) Diet Pattern 1: 45% Diet Pattern 2: 15% Diet Pattern 3: 9% Diet pattern 1 explained ~64%, 51% and 20% of the variation in dietary energy density, fibre density and % energy from fat, respectively Compared with lowest quintile for the DP score, those in the highest quintile had a 22% higher odd of excess adiposity (OR 95% CI, 10–35%)
Grieger, et al (2011) [32]	PCA	2x 24-hour recall	n=2287 2- 8 years Australia	Breastfeeding BMI	+BMI	3 dietary patterns explained 4.2%, 4.1% and 3.7% of the variance in dietary patterns
Wosje, et al (2010) [469]	RRR	3 x FR	n= 325 3.8–7.8 years US	Bone Mass Fat Mass	+Fat Mass	DP1 explained 13.4–19.2% fat mass; DP2 explained an additional (i.e., after DP1) 3.3–5.2% fat mass;

Finding: Positive Association with outcome (+); Negative Association with outcome (-)

PCA: Principle Component Analysis; RRR: Reduced Rank Regression; FFQ: Food Frequency Questionnaire; FR: Food Record

Appendix 2: Characteristics of childhood eating behaviour and obesity studies

Reference	Eating Behaviour measures	Participants (no., age, location)	Outcome focus	Findings
Webber, et al (2009) [5]	CEBQ	n= 406 7 -12 years UK	Eating behaviour & BMI	Each unit increase in: • Food responsiveness = 0.39 increase BMI s.d (p<0.0001) • Enjoyment of food = 0.25 increase BMI s.d (p=0.003) • Emotional overeating = 0.41 increase BMI s.d (p<0.0001) • Desire to drink = 0.16 increase BMI s.d (p=0.037) Each unit increase in: • Satiety responsiveness/ slowness in eating = 0.49 decrease BMI s.d. (p<0.0001) • Food fussiness = 0.27 decrease female BMI s.d (p= 0.008; no significant association with boys)
Haycraft, et al (2011) [6]	CEBQ ESA	n= 241 3-8 years UK	Eating behaviours & temperament	BMI positively correlated to: • Food responsiveness = 0.32 • Emotional over-eating = 0.24 • desire to drink = 0.32 BMI negatively related to: • slowness in eating = -0.21 Enjoyment of food, satiety responsiveness, emotional under-eating, food fussiness not significantly correlated with BMI Child BMI not correlated to temperament traits
Spence, et al (2011) [7]	CEBQ	n=1730 4-5 years Canada	Eating behaviours & weight	Positive linear patterns by weight for: • food responsiveness (p< 0.01) and enjoyment of food (p< 0.01) Negative linear patterns by weight for: • satiety responsiveness (p< 0.01), slowness in eating (p< 0.01), and food fussiness (p< 0.01)
Carnell, et al (2008) [55]	CEBQ – SR/SE CEBQ - EF	n = 10 364 8–11 years; n = 572 3-5 years England	Adiposity and 2 appetitive traits: satiety responsiveness & food cue responsiveness	Negative linear trend in satiety responsiveness/slowness in eating across BMI categories Positive linear trend in enjoyment of food across BMI categories 3 – 5 years • Satiety responsiveness = - 0.19 BMI s.d • Enjoyment of food = 0.18 BMI s.d 8 – 11 years

				• Satiety responsiveness = - 0.22 BMI s.d; -0.23 waist s.d • Enjoyment of food = 0.18 BMI s.d; 0.20 waist s.d
Dubois, et al (2007) [63]	Adapted ALSPAC	n=1498 2.5, 3.5 & 4.5 years Canada	Social factors, eating behaviours & body weight	• Being a picky eater from 2.5 to 4.5 years increased the odds of being underweight at 4.5 years by 2.4 (95% CI 1.4–4.2) • Overeaters at one or two of the ages increased odds of risk of overweight by (2.1, 95% CI 1.5–3.1) and the odds of overweight by 2.9 (95% CI 1.9–4.5) • Overeaters at all 3 ages increased odds of risk of overweight by 3.2 (95% CI 1.7– 6.1) and increased the odds of overweight at 4.5 years by 6.1 (95% CI 3.3–11.2) Picky eater from income-insufficient families: • At 3.5 years (22% vs. 16%) • at all three ages (9% vs. 5%) Overeaters from income-insufficient families: • At all three ages (12.5% v 6.2%)
Silva, et al (2013) [470]	DEBQ-C	n= 453 children 7 - 12 Chile	Restrained, external, and emotional eating, & BMI	• BMI + association with restrained eating • BMI – association with external eating, emotional eating
Parkinson, et al (2010) [64]	CEBQ	n= 1029 infants CEBQ at 5–6 years, and body mass index (BMI) at 6–8 years Gateshead Millennium Study, England	A longitudinal birth cohort maternal ratings of children's appetites made at 6weeks, 12months and 5– 6 years	BMI tertiles + with: • Emotional over-eating • Enjoyment of food • Food responsiveness • Desire to drink had higher • Appetite rating at 5–6 years BMI tertiles – with: • Satiety Responsiveness • Slowness in eating
Croker, et al (2011) [56]	CEBQ	Community (n = 406) and clinical (n = 66) 7-12 years UK	Appetite and adiposity in clinical samples of obese children	Positive linear trend in BMI s.d with: • Responsiveness and emotional overeating Negative linear trend in BMI s.d with • Satiety responsiveness/slowness in eating
Sleddens, et al (2008) [57]	CEBQ	n = 135 6 – 7 years Netherlands	Eating behaviours & weight	Food approach scales + BMI • Food responsiveness (β = 0.217, p=0.016) • Enjoyment of food (β = 0.207, p=0.027) • Emotional overeating (not significant) Food avoidant – BMI • Satiety responsiveness (β = -0.240, p=0.006)

				• Slowness in eating (β = -0.248, p=0.006) • Emotional undereating (not significant) • Food fussiness (not significant)
de Barse, et al (2015) [471]	CEBQ DEXA	n=4191 Baseline 4 years Netherlands	Fussy eating at 4 years longitudinally related to BMI, fat mass index (FMI) and fat-free mass index (FFMI) at 6 years	• Fussy eating - associated BMI s.d; FMI s.d; and FFMI s.d • Fussy eating at 4 years predicted a 0.11 lower BMI s.d at age 6. This change in BMI was mainly due to a decrease in FFMI • Fussy eaters also had a higher risk of becoming underweight than non-fussy eaters
Ashcroft, et al (2008) [62]	CEBQ	n= 322 Twins 4 to 11 years UK	Longitudinal continuity and stability of eating behaviours	Longitudinally: • satiety responsiveness, slowness in eating, food fussiness, and emotional undereating decreased; • food responsiveness, enjoyment of food and emotional overeating increased
Mallan, et al (2014) [60]	CEBQ EAH	n=37 4.4 years **Australia**	Prospective examination of pre-schoolers' eating behaviour styles as predictive of observed eating behaviour (EAH) and weight	EAH energy intake associated with: • Satiety responsiveness (partial r = −.40, p = .023) • Slowness in eating (partial r = −.40, p = .023) BMIz associated with: • Satiety responsiveness (partial r = −.42, p = .015) Food responsiveness & enjoyment of food were not related to energy intake or BMIz None of the eating behaviours were significantly associated with EAH
Derks, et al (2018) [61]	CEBQ	n=3331 4 – 10 years Netherlands	Prospectively examine both directions of the association between eating behaviour and body composition across childhood	Higher BMI at the age of 4 years predicted at 10 years: • more food responsiveness • more enjoyment of food • less satiety responsiveness • no associations were found in the opposite direction • For emotional overeating a bi-directional association was found with BMI
Quah, et al (2015) [472]	BEBQ CEBQ	n=210 3 months & 24 months Singapore	Prospective associations between BEBQ & CEBQ and BMI	Food responsiveness at 3 months: • associated with higher BMI from 6 months up to 15 months of age ($p < 0.01$) • greater weight gain between 3 and 6 months of age ($p = 0.012$) Slowness in eating and satiety responsiveness at 3 months: • associated with lower BMI at 6 months ($p < 0.01$) • less weight gain between 3 to 6 months of age ($p = 0.034$) • None of the appetitive traits at 12 months were significantly associated with BMI or weight gain prospectively

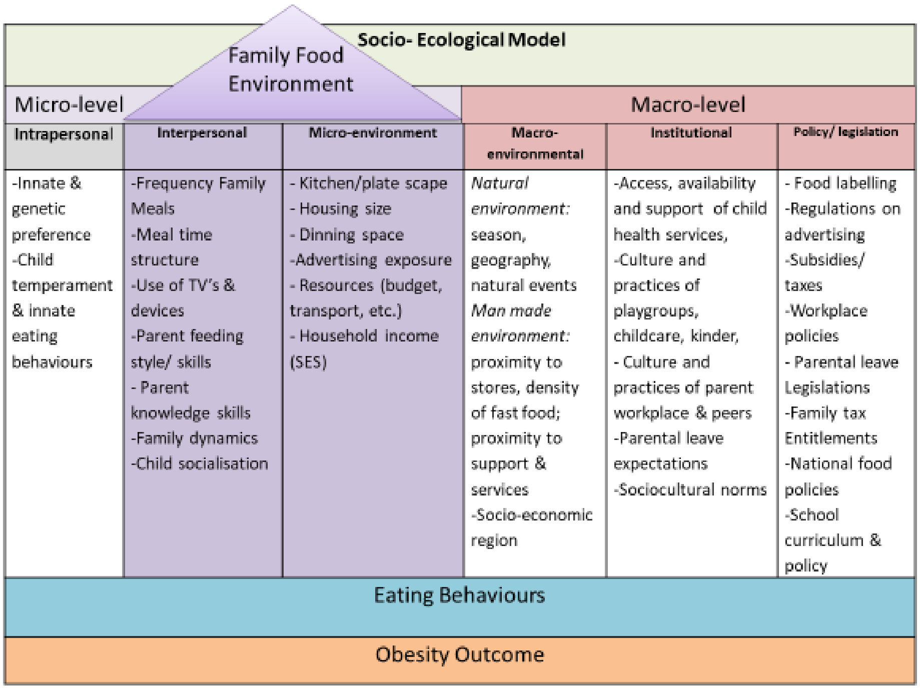
van Jaarsveld, et al (2011) [59]	BEBQ	n=2213 Twins 6months – 15 months UK	Compare prospective associations between eating behaviours and weight in both directions	From 6 – 15 months: • The path from appetite to subsequent weight: standardized coefficients: 0.17–0.33 • The path from weight to subsequent appetite: standard coefficients: 0.07–0.13
van Jaarsveld, et al (2014) [58]	BEBQ	n=172; n=121 Twins 6months – 15 months UK	Determine if sibling differences in infant appetite predicted differential weight gain during childhood	Twin with higher Food responsiveness: • 654g heavier (95% CI, 395-913) at 6 months • 991g heavier (95% CI, 484-1498) at 15 months Twin with higher Satiety responsiveness: • 637g lighter (95% CI, 438-836) at 6 months • 918g lighter (95% CI, 569-1267) at 15 months
Eating behaviour and dietary intake studies				
Reference	**Eating Behaviour/ Dietary Intake measures**	**Participants (no., age, location)**	**Outcome focus**	**Findings**
Dubois, et al (2007) [69]	Adapted ALSPAC 24hour recall	n=2103 2.5, 3.5 & 4.5 years Canada	Eating behaviours, diet adequacy & weight	• Picky eaters= less total fats, energy, protein, fruit, vegetables, meat and alternatives • Overeaters = more total energy, macronutrients
Mallan, et al (2015) [68]	CEBQ CDQ	n= 340 14months & 3.7 years **Australia**	Diet Quality, food preference, eating behaviours & weight	• Greater no. fruits and vegetables tried at age 14 months = greater liking no. fruits at age 3.7 years (β= 0.16, P=0.007; β=0.14; P=0.022) • Fewer vegetables tried at age 14 months + associated increased fussiness score at age 3.7 years (β=0.47, P<0.001) • Greater no. noncore foods tried at age 14 months = greater liking for noncore foods at age 3.7 years (β=0.20, P=0.001) • No association child BMI z score at age 3.7 years
Fildes, et al (2015) [67]	CEBQ Food preference Survey	n= 1211 16months or 3-4 years **Australia** & Brittan	Appetite & food preferences (3 categories; vegetables, fruits and noncore foods)	Vegetable liking: • + associated with enjoyment of food; • - associated with satiety responsiveness, slowness in eating and food fussiness Fruit liking: • +associated with enjoyment of food; • - associated with satiety responsiveness, food fussiness and slowness in eating Non-core food liking: • + associated with food responsiveness
Carnell, et al (2016) [473]	CEBQ-SR CEBQ-FR CEBQ-EF	n=123 - 108 4-5 years	Pre-load study Children from 5 pre-schools served 5 lunchtime meals	Despite differing preload conditions: • consistency of intake patterns across all five meals with day-to-day • intake of each food category ranging from 0.78 to 0.91

				CEBQ-Satiety responsiveness was associated with: • lower mean intake of all food categories across all five meals, with the weakest association for snack foods CEBQ-Food responsiveness was associated with: • higher intake of white bread, fruits, vegetables CEBQ-Enjoyment of food was associated with: • greater intake of all food categories, with the strongest association for white bread BMIz was associated with: • absolute intakes of white bread and snack foods CEBQ sub-scale associations with food intake variables unchanged by controlling for daily metabolic needs
Russell, et al (2016) [474]	CEBQ Healthy Preference Index scores	n=371 2-5 years Australia Melbourne (44.20%) and Adelaide (55.80%), Australia	Children's appetitive traits and patterns of food preferences	Fussiness predicted: • all the measures of food preferences, explaining a large proportion of the variance in such measures (ranging from 23% to 59%). Enjoyment of food predicted liking of: • Vegetables and meats • higher variety index score. Food responsiveness was associated with liking of: • Liking of non-core extra foods • Reduced preferences for vegetables

Baby Eating Behaviour Questionnaire (BEBQ); Child Eating Behaviours Questionnaire (CEBQ); CEBQ sub scales: Food Responsiveness (FR), Satiety Responsiveness (SR), Enjoyment of Food (EF), Slowness in Eating (SE); standard deviation (s.d); Colorado Childhood Temperament Inventory (CCTI); New York Longitudinal Study (NYLS); EAS Temperament Survey for children (ESA); Avon Longitudinal Study of Parents and Children (ALSPAC); Children's Dietary Questionnaire (CDQ); 21-item version of the Three-Factor Eating Questionnaire (TFEQ-R21); Children's Dutch Eating Behaviours Questionnaire (DEBQ-C); Eating in the absence of hunger (EAH);

Appendix 3: Macro level influences on the family food environment

As has been acknowledge throughout chapter 2 of this thesis; health opportunities are not distributed randomly within populations, but are embedded in social, cultural, economic, environmental, and political circumstances. [51] While micro-level influences on children's eating behaviours and obesity status have been the focus of the literature reviewed, it is not without acknowledgement of the distal influences, as described as the macro-system (macro-environment, institutional and political) within the socio-ecological model. [12, 52-54] These macro-level influences on the FFE are reviewed below.



As has been discussed, individual's psycho-social factors increase vulnerability to environmental influences on eating behaviours and consequently obesity status within the confines of the FFE. These individual vulnerabilities are further likely to extend to macro-level influences, and as such have a broader reaching effect across communities and population groups. That is, determinants such as cultural diversity, community level SES, and geographic proximity, for various reasons, increase vulnerability to macro-level influences such as food marketing and media messages, social norms and food cues, food production and distribution systems, food and nutrition policies and various legislation and policies. [9, 21, 54, 475] Establishing such connections between the levels and domains of the socio-ecological model has important implications for obesity prevention initiatives. [475]

Culture

Australia is a multi-cultural nation, with one in four people born overseas (2011), each bringing with them a unique cultural heritage, which includes learned food preferences, perceptions of what kinds of foods are healthy and unhealthy, what food is acceptable to eat and on what eating occasion. [15, 476] Although these cultural food practices are often seen to be maintained in first generation immigrants, it is accepted that through acculturation original cultural patterns are replaced with the cultural practices in which they have become immersed, typically at the detriment of obesity 'protective' behaviours. [15, 476] Within Australian these shifts in culture towards *Western* practices can be seen to occur through exposure to different types of foods, many of which are highly processed and energy dense foods; differences in accepted and industry driven portion sizing; variations in marketing strategies, exposure, and representation of cultural ideals and norms; and, perceived risks of obesity and perceptions of body image ideals. [9, 21]

Although cultural differences are noted in obesity development at micro-environment and interpersonal levels, as previously discussed, difficulty exists in quantifying cultural differences at a macro-level in isolation of other macro-level constituents, such as community SES, which within itself carries sets of cultural practices, world views, and social norms. During early childhood, accessing community childcare/kindergarten services, playgroups/parenting groups, parent's place of work and other social settings, provides avenues for cultural practices, world views and social norms to be disseminated. As previously mentioned, friends and family are key sources of child feeding information for parents so these avenues are likely to be significant, although access to services can be seen to vary between cultural groups. [229]

Despite uniqueness in cultural beliefs and practices which may impact upon the FFE at interpersonal and micro-environment levels, cultures are seamed together at the macro-level by shared environments, policies, media exposure and marketing strategies.

Community socio-economic status

Health inequities exist between the top and bottom SES quintiles of the Australian population. [477] As consistent with what is seen in Australian adults, Australian children (5-14 years) that come from low SES communities are more likely to be overweight or obese compared with children from high SES communities (33% vs 19%). [10, 19, 20]

Unlike interpersonal measures of SES, such as household income, at the macro level, community SES can be measures using socioeconomic index for areas (SEIFA) or the index of relative socioeconomic disadvantage (IRSD), which provide an area-level index of disadvantage based on census data for factors such as income, education levels, levels of public sector housing, unemployment, and jobs in relatively unskilled occupations. [477, 478] Much research has focused on comparing factors within SEIFA or IRSD to determine contributions to obesity inequalities. Specifically, an audit conducted within 35 Australian supermarkets in 2013 compared the number of different product varieties and supermarket shelf space allocation between SES regions. [184] Results from this investigation revealed that the most disadvantaged areas had 23.6m of shelf space allocated to soft drink, compared with 17.7m in the least disadvantage areas; 16.5m allocated to crisps compared with 13.0m; 12.2m allocated to chocolates compared 10.1m; and 6.7m allocated to confectionary compared with 5.1m (all $p<0.05$). [184] The ratios of shelf space allocated to fruits and vegetables to energy-dense snack foods and soft drinks for most disadvantaged areas was 1.7 compared with 2.1 for least disadvantage areas ($p=0.025$). [184]

Although it is expected that such allocations would contribute to differences in purchasing behaviours between SES regions, this has not been consistently found within the literature. An Australian study of 625 children 9-13 years found that while low socio-economic position (SEP) was associated with higher intake of non-core foods and sweet drinks and lower intake of fruits, vegetables, SEIFA was least frequently predictive of children's dietary intake. [478] The idea that SEP (interpersonal level) maybe of greater influence on diet than community SES (macro-level) has also been suggested in a study of 1399 Australian women (18-65 years) from 45 neighbourhoods of varying socio-economic disadvantage which found that women in highly disadvantaged areas reported less frequent fruit and vegetable consumption and more frequent fast-food consumption, however, only associations for vegetable and fast-food consumption remained significant after adjustment for individual SEP, which suggested that fruit consumption may be more influenced by individual factors than neighbourhood factors, as has been discussed in relation to neurobiological drivers of eating behaviours and appetite. [479] Similarly, fruit and vegetable price was positively associated with intake, with more frequent consumers exposed to higher prices in both greengrocers and supermarkets. [479] Those who reported never consuming fast food were also exposed to a higher density and variety of fast-food restaurants. [479] In this study higher fast food density and variety was reported in low disadvantaged areas, which is contrary to other studies, as will be discussed in the following section. [479]

The studies presented in this section, as with most in this field, have considered intake of various foods and beverages and not considered eating behaviours which may offer differing insight to obesity promoting or protective behaviours at a community SES level.

Proximity to shops, restaurants, take-away

As mentioned, density of fast food outlets has been noted to vary according to community SES and although not conclusive, is expected to have an impact on purchasing behaviours.

In a study including 380 children (137 aged 8 - 9 years and 243 aged 13 -15 years) and their parents (n=322 fathers and n=362 mothers), 81% of participants had a fast food outlet within 2 km of their home. [480] In this study, having at least one outlet within 2km of the home was associated with lower BMIz. [480] Consistent with this, fathers that lived further from a fast food outlet had a higher BMI, with the likelihood of overweight or obesity reducing for fathers and their daughters (13-15 years) by 50% and 80% respectively, if they had at least one fast food outlet within 2 km of their home. [480] Similarly, among 13 – 15 year old girls, the likelihood of being overweight or obese was reduced by 14% with each additional outlet within 2 km. [480] These findings, although contrary to what might be expected, are supported by a further study of 353 children aged 5–6 years and 463 children aged 10–12 years, which found that despite 69.4% of children consuming takeaway/ fast foods once or more per week, the availability of outlets close to home was not associated with consumption. [481] For each additional outlet within 800m of the home, the odds of takeaway/ fast foods consumption at least once weekly lower by 3% (OR=0.97, 95% CI 0.95, 1.00). [481] Based on the unexpected findings of this study, in particular the fact that 62% of participants usually ate takeaway or fast food with a parent, it was suggested that rather than simply the proximity of fast food outlets, parents were likely to play an important role in mediating a child's access. [481] Alternatively, however, author of this study suggested that these unexpected findings, albeit consistent with a wider body of research, could be explained due to limitations in measuring exposure, such as not controlling for duration of residency, the duration the fast food outlet had been operating, and/or examination of the available menu. [480, 481]

Consistent with this, a comparison of purchasing behaviours and density of health food stores (defined as supermarkets, general stores, fruit and vegetable stores, and butchers) with fast food outlets, in a study of 1850 children (5 – 15 years, Perth), showed that after adjusting for control variables, children with access to at least one health food outlet within 800m of their home had a 38% decreased risk of being overweight/obese compared to those with no health food outlets. [482] Similarly, however, and as consistent with the previous research, children with access to at least one fast food outlet within 800m also had a 31% decreased risk of being overweight or obese, compared to those with no fast food outlet within 800m of their home. [482] When food outlet variables were examined alongside control variables in multivariable models, however, only 5% - 7% of the total variance in weight was explained. [482] This latter finding again appears consistent with the idea that additional factors, such mediation by parent's, may be important in explaining these relationships.

Food manufacturing and marketing:

Whilst factors such as convenience, cooking skills, flavour preferences and the desire for value for money, have been discussed as influences of eating behaviours and obesity risk operating at an intrapersonal, interpersonal and micro-environment levels of the socio-ecological model, these variables are also influenced by upstream, macro-level factors. That is, food manufacturers and marketers, as regulated at a macro level, often aim to appease and reinforce micro-level preferences and desires by developing and marketing food products that are cheap, quick and easy to prepare, and highly palatable. [476] This influence of food manufacturing and marketing on micro-level variables within the FFE will be discussed in this section, while the distinct impact of food advertising will be considered in the following section.

Within Australia the vast majority of consumers frequently shop at supermarkets, with two major chains monopolising the grocery retail sector. [483] Between 1990 and 2008, the number of food and beverages products sold within supermarkets in Australia increased by 67%, to shelve 19,540 products. [484] The variety of confectionery alone within supermarkets ranged from 145–190 different products. [485] Children and families can be expected to make up a significant market share for these retailers and the food manufactures that fill their shelves. Consequently, an investigation into marketing and promotions targeting children within 9 Australian supermarkets showed that within seven food categories, between 9% and 35% of food products used promotional tactics, 82% of which were for foods categories as unhealthy. [485] Children were reported to be the main target audience for these food promotions with 100% of promotional activity within the confectionery, sweet biscuit, chips/savoury snacks, dairy snacks and ice cream categories. [485] Television/ movie celebrities and cartoon characters were the most common promotions used, making up 75% of all promotions. [485] Confectionery products had the highest proportion of promoted products with an average of 35% of promotions, snack foods and dairy snacks also had high proportions with 30% and 31%, respectively, although some of these product were considered to be healthy choices. [485] These types of marketing tactics are designed to create food cues associations and trigger ‘liking’ and ‘wanting’ of these foods, as discussed in chapter 2.2. [174]

Further to this, the retailers themselves employ marketing tactics, such as loyalty cards, to increase purchasing within their stores and tailor purchasing incentives and marketing. These programs provide a sophisticated way for retailers to gather data on customer’s behavioural shopping patterns, which are then linked to customer demographic data. Such schemes are often used to encourage purchasing of processed foods through use of rewards on selected items. Although such data reflecting the influence of loyalty cards is unavailable, in general, such promotional and marketing efforts target the most easily influenced consumers. [476] In this regard, in addition to targeting children directly it is plausible that various market segments such as low SEP, single parents, or those with predispositions towards food approach eating behaviours (e.g. high food cue responsiveness), as have been identified to be at greater risk of obesity, are more vulnerable to the effects of marketing.

It could similarly be hypothesised that, although regulations are imposed within food manufacturing to limit the use of misleading claims and marketing tactics, these regulations may favour certain segments of the population thus leaving other segments more vulnerable to poorer food purchasing behaviours. [486] This effect can be seen with the government driven *‘Health Star Rating System’* which aims to provide consumers with clear, accurate information on the healthiness of products based on a 5 star rating system. [487] This system, however, has been reported to have only a modest effect on the purchasing behaviours of young families (oldest child < 6 years) compared with other population segments. [487] This finding was revealed in a consumer research study of 4,171 Australian adults, 637 of which were identified to be from young families. [487] This research further found that star ratings above 3 (with 5 being the highest) were generally associated with higher consumption of the product (up to 37.1% in the case of salted snacks rated 3-4 stars), while ratings below 3 tended to be associated with decreases in consumption (up to 15.5% in the case of lunchbox fillers rated 1½ stars and under). [487] Although this study collected data on participants household income, level of education, work situation and cultural background, these were not analysed to determine if they influenced use of the system.

Consumer group Canstar Blue similarly surveyed 3002 Australian adults in 2015 regarding use of the Health Star Rating System, with 58% reporting the system easy to understand and helpful in understanding what foods are good for them (60%), however, less than half of responders (48%) stated that the Health Star Rating System had, or would have, an impact on their purchase decisions. [488] Over two-thirds (68%) of responders found it confusing that some seemingly unhealthy foods carry high star ratings and some healthy foods have low ratings. [488] Young Australians (aged 18-29 years) reported to be least likely to find the ratings easy to understand, helpful, and to consider the rating in their purchase decisions, which seems to be consistent with the consumer research previously discussed. [487, 488] Although these responses may reflect flaws in this public health initiative, it may also indicate support for the hypothesis that certain groups of consumers are likely to be more vulnerable to marketing tactics.

Advertising to children:

As with food manufacturing and marketing, tactics employed via advertising and sponsorship aim to appease interpersonal and intrapersonal factors to influence 'liking' and 'wanting' for particular products. [174] The Australian Communications and Media Authority oversees The Commercial Television Industry Code of Practice (the Code) which stipulates that food and/or beverages advertisements directed to children (younger than 14 years) should not encourage or promote an inactive lifestyle; should not encourage or promote unhealthy eating or drinking habits; and must not contain misleading or incorrect information about the nutritional value of the product. [489] The Children's Television Standards, which runs alongside the Code, further sets out standards related to advertising to children, however, as these standards are industry-regulated many parent and advocacy groups perceive these standards to be insufficient in protecting children from persuasive advertising. [489, 490]

Analysis of one weeks' worth (741 hours) of Australian television from commercial channels revealed that of the 20,201 advertisements that aired during the analysis period, 25.5% were for food, with the most frequent category of advertised foods being non-core foods, comprising 56.4% of all ads and increasing to 61.3% during children's peak viewing times, based on viewing patterns of children 5-12 years old. [490] Of all food advertisements, 21.4% contained promotional characters, 54.3% of which were for non-core foods and 7.3% used premiums offers, 84.5% of which were for non-core foods. [490] Significantly more food advertisements broadcast during children's peek viewing times, compared to non-peak times, contained promotional characters ($p < 0.05$) and premium offers ($p < 0.001$). [490] During the most popular children's programming 3.3 non-core food advertisements per hour containing premium offers were recorded, compared with 0.2 per hour during the most popular adult programs. [490] This study, however, was conducted prior to the implementation of the food industries two voluntary self-regulatory initiatives in 2009, the Australian Food and Grocery Council's Responsible Children's Marketing Initiative and the Quick Service Restaurant industry initiative, which aim to address the concerns expressed by parents and advocacy groups by offering improved standards on advertising to children. [491]

A systematic review aiming to examine the amount of advertising of non-core foods to children on Australian television since the introduction of the Responsible Children's Marketing Initiative and the Quick Service Restaurant industry initiative, found that the rate of non-core food advertising on metropolitan free to air television during children's peek viewing times was at least double the rate reported by the AFGC (1.5 per hour) at between 3.1 and 5.9 advertisements per hour. [492] Meanwhile, the rate of non-core food advertisements on regional free to air television during children's peek viewing times have steadily declined from 6.5 to 2.7 per hour. [492] It is not possible to determine whether this rate is consistent across regional areas but, in comparison to rates reported in metropolitan areas, this does serve to highlight variations in population subgroups which may contribute to differing obesity outcomes in sub-population groups as noted. As consistent with the study previously reported, 50% – 60% of all food advertised was non-core, however, the percentage advertising during children's peek viewing times was reported to be higher at ~70%, ranging from 0.7 to 6.5 advertisements per hour. [492] This study ultimately concluded that since the introduction of the Responsible Children's Marketing Initiative and the Quick Service Restaurant industry initiative, the rate of advertising of non-core foods during children's peek viewing times has always been higher among signatories of the initiatives compared with non-signatories, with multiple breaches of the industry initiatives and of the Children's Television Standards, highlighting the limitations of voluntary, self-regulated initiative. [492]

Although the data presented in these studies have typically focused on children from the age of 5 years, it can be expected that the effect of advertising starts much younger than this with a study into brand recognition identifying children as young 2 are able to recognise 7.76 brands out of 12 (64%) presented and can recall 1 (8%), increasing to 10.29 (85.75%) and 1.86 (15.5%) respectively by 4 – 5 years. [493] Although mean brand recognition and recall during early childhood was lower than that of older children (11.72 [97.6%] and 4.97 [41.4%], respectively for children 8 years old), it is clear that the effects of advertising begins from early in life and rapidly increases with age. [493] Further to this, results from this study showed that frequency of television viewing was significantly related to the brand awareness even among the youngest children ($\beta=0.16$; $p<0.05$). [492] Parental brand awareness was related only to children's brand recall ($\beta=0.19$; $p< 0.001$), while family education level was only related to brand recognition ($\beta=0.18$; $p<0.01$). [492] Family income was unrelated to either brand recognition or recall. [492] Peer influences were also seen to significantly predicted brand recognition ($\beta=0.13$; $p<0.05$); however, this was across children of all ages and did not distinguish this effect on younger children where it can be expected the influence would be less significant. [492]

As can be seen, marketing, manufacturing and media tactics used to influence purchasing decisions that shape the FFE may work by directly influencing children's recognition of products or brands or by targeting parents. [492] Data reflecting the impact of manufacturing, marketing and media on influencing the FFE in early childhood is, however, limited and warrants greater attention, as does data exploring the effect of such influences with different segments of the population, to better inform obesity prevention efforts in early childhood. As is the premise of the socio-ecological model, affecting change at these up-stream levels will have a follow-on effect on down-stream behaviour and consequently enable greater changes within the FFE to support healthful eating behaviours and reduced obesity development.

Appendix 4: Summary of FFE focused early childhood feeding RCT

Reference	Sample	Intervention/ outcome focus	Assessment measure/ protocol/delivery	Results
Duncanson, et al., (2012) [334] Duncanson, et al (2016) [333]	n= 146 2 – 5 years 3 month & 12month data collections **Australia** (rural towns)	Feeding Healthy Food to Kids (FHFK) RCT The impact of providing low cost, self-directed nutrition and parenting resources to rural parents, on child dietary intake and parent-child feeding practices	Intention to treat Theory of planned behaviour Intervention – resources (books, brochures, CD; email/text/phone reminder to use resources) Control – 12 month wait list (blinded; generic resources) Primary outcomes: - intake of vegetables (serves/day), fruit and energy dense nutrient poor foods (serves/day and %Energy). Secondary outcomes: - Total energy (kCal), other food groups (serves/day and %Energy), key nutrients (mg/day), - child feeding domains and parenting style domains <u>Measures:</u> - ATES FFQ - CFQ - LSAC parenting questions	<u>Intervention group:</u> - Monitoring scores significantly lower (4.2 vs 4.6, $p < 0.05$) - Other CFQ were consistent between baseline and 12 months ($p < 0.001$) - Parenting dimension warmth had significantly increased from baseline (0.19, $p = 0.02$) - Overprotection increased from baseline (0.29 $p = 0.02$) - No changes in control group
Ball, et al., (2017) [369]	N= 28 parent peer educations Peer educator child age 0 – 3 years **Australia**	Peer educations program	Qualitative study Theory of planned behaviour Peer Education Training 1 x 2hour face-to-face workshop Protocol:	<u>Four outcome themes:</u> - influences on sharing - sharing mediums - pitching the message - support for peer educators <u>Peer educators reported:</u> Influences on sharing - Increased own nutrition knowledge - Improved own child feeding practices

			- 6 months peer education delivery (e.g. peer educators providing education to friends/family) - Print/email resources - Facebook® page (1 - 4 posts per day [total 311 per 6 months] by the Principal Investigator) - Phone contact with peer educators 2 – 4 months into intervention	- Positive changes to their own child(ren)'s diet - Confidence in providing education decreased if parents expressed strong beliefs that contradicted the evidence-based information being shared - Family reluctant to receive peer education Sharing mediums - verbal information sharing was considered to allow responsive, impromptu information sharing, catering more specifically to parents' needs than Facebook® posts - Facebook® was an ideal medium for sharing messages with parents who required assistance, without it appearing that they were being targeted - regular Facebook® users described the ease with which information could be shared/ accessed - Facebook® allowed continued engagement in the study and the sharing process - print and email resources were the least preferred sharing mediums Pitching the message - nutrition messages were very familiar but hard to implement without accompanying behavioural strategies - Messages require minimal effort to engage with were most popular - Messages emphasising parent benefits in addition to child benefits were considered easier to share (e.g. 'division of responsibility') Support for peer educators - Positive feedback from parents after implementing suggested feeding strategies strengthened peer educators resolve - Peer educators reported feeling adequately supported by the research team
Militello, et al., (2014) [331] Militello, et al., (2016)	n= 15 parent-child (3 – 5 years) dyads Intervention (no control group)	Feasibility, acceptability, and preliminary effects of a cognitive behavioural intervention synergized with	Beck's cognitive theory & Fogg's behaviour model (cognitive behavioural skills) 7-week intervention - 4 face to face sessions (20-30mins) - **SMS text messaging** (tailored, static & automated feedback text messages; mean no. of text 22.31 (SD 9.47))	<u>Intervention group</u>: - improved nutrition knowledge (p= 0.001) - improved healthy lifestyle behaviours (p=0.04) - no change in perceived difficulty (p=0.16) - improved parent belief in ability to engage in a healthy lifestyle (p=0.001) - BMI outcomes not reported

[494]	**US**	tailored mobile technology (mHealth) for overweight/obese pre-schoolers		Acceptability: - 100% parent helpful - 100% would recommend - 100% retention rate
Haire-Joshu, et al., (2008) [223]	n= 1306 (control n=899; intervention n=759) 2 to 5 years **US**	SLU4Kids RCT to Increase knowledge & parent behaviour	Social cognitive theory Ecological framework 5 x home visits + Onsite group activities (e.g. child care setting) + newsletter <u>Measures:</u> - Dietary intake (FFQ) - child-feeding practices, - parent modelling of fruit & vegetable intake, - nutritional knowledge - availability of fruit and vegetables in the home	<u>Compared to control improved:</u> - intake of fruit (mean servings=.14, p=0.04) - intake of combined FV (mean servings=.20, p=0.05) - Fruit and vegetable availability in home (p=0.01) - Fruit and vegetable knowledge (p=0.01) - Non-coercive feeding practices (p=0.02)

Appendix 5: The family food environment survey (Survey 1)

Personal details (DOB, parent DOB, parent and child gender)	
Child details	
Q1: how old is your child (if you have more than one child between 2 and 5 years, please refer to the child whose birthday is next)	2 2.5 3 3.5 4 4.5 Almost 5
Q2: Please select your child's gender	Male Female
Q3. Does your child have a disability or medical condition that affects their growth, development or metabolism?	Yes No
Parent details	
Q5. Please select your gender	Male Female
Q6. Are you a single parent?	Yes No
Anthropometric	
Q7. What is your child's weight in kilograms? Please provide your child's weight as a whole number closest to their current weight (e.g. 12). If possible please weigh your child using bathroom scales.	continuous
Q8. What is your child's height in centimetres? Please write your child's height as a whole number in centimetres (e.g. 112). If possible measure your child's height using a household tape measure.	continuous
Q9. What is your weight in kilograms? Please provide your child's weight as a whole number closest to their current weight (e.g. 12). If possible please weigh your child using bathroom scales.	continuous
Q10. What is your height in centimetres? Please write your child's height as a whole number in centimetres (e.g. 112). If possible measure your child's height using a household tape measure.	continuous
Q11. How many hours does your child sleep each night?	continuous

Q12. Was your child ever breastfed	No, never breastfed Yes, for less than 3 months Yes, for between 3 and 6 months Yes, for between 6 and 12 months Yes, for more than 12 months
Q13. What is your household's annual income?	less than $40,000 $40,000 - 100,000 More than 100,000
Which state do you live in?	Victoria New South Wales Queensland Australian Capital Territory Western Australia Tasmania Northern Territory South Australia
Q14. What type of area do you live in?	Capital city; Metropolitan centre (population over 100,000); Large rural centre (population 25,000-99,999); Small rural centre (population 10,000-24,999); Large Remote centre (population up to 5,000); Small remote areas (population less than 5,000)

Children's eating behaviour questionnaire (CBEQ) [35, 67] Scale: Never; Rarely; Sometimes; often; Always	
Enjoyment of food	
EF1	Q15. My child loves food
EF2	Q16. My child is interested in food
EF3	Q17. My child looks forward to mealtimes
EF4	Q18. My child enjoys eating
Food Responsiveness	
FR1	Q19. My child is always asking for food
FR2	Q20. If allowed to, my child would eat too much
FR3	Q21. Given the choice, my child would eat most of the time
FR4	Q22. Even if my child is full up s/he finds room to eat his/her favourite food
FR4	Q23. If given the chance, my child would always have food in his/her mouth
Satiety responsiveness	
SR1	Q24. My child has a big appetite
SR2	Q25. My child leaves food on his/her plate at the end of a meal

SR3	Q26. My child gets full before his/her meal is finished
SR4	Q27. My child gets full up easily
SR5	Q28. My child cannot eat a meal if s/he has had a snack just before
Slowness in eating	
SE1	Q29. My child finishes his/her meal quickly
SE2	Q30. My child eats slowly
SE3	Q31. My child takes more than 30 minutes to finish a meal
SE4	Q32. My child eats more and more slowly during the course of a meal
Food fussiness	
FF1	Q33. My child refuses new foods at first
FF2	Q34. My child enjoys tasting new foods
FF3	Q35. My child enjoys a wide variety of foods
FF4	Q36. My child is difficult to please with meals
FF5	Q37. My child is interested in tasting food s/he hasn't tasted before
FF5	Q38. My child decides that s/he doesn't like a food, even without tasting it
Feeding strategies & meal structure questionnaire (FPSQ-28) [243, 244] Scale: 1. Disagree; Slightly Disagree; Neutral; Slightly agree; agree 2. Never; Rarely; Sometimes; Often; Always	
Reward for behaviour	
RB2	Q39. I offer my child his/her favourite foods in exchange for good behaviour.[1]
RB3	Q40. In order to get my child to behave him/herself I promise him/her something to eat[2] e.g. "if you behave at the shop I will buy you a lolly"
RB4	Q41. I reward my child with something to eat when (s)he is well behaved[2]
RB5	Q42. I give my child something to eat to make him/her feel better when (s)he is feeling upset[2]
Reward for eating	
RE3	Q43. Do you encourage the child to eat something by using food as a reward (for example, "If you finish your vegetables, you will get some fruit)?[2]
RE4	Q44. When your child refuses food they usually eat, do you encourage to eat by offering a food reward?[2]
RE5	Q45. I use desserts as a bribe to get my child to eat his/her main course[2]
RE6	Q46. Do you warn the child that you will take a food away if the child doesn't eat (for example, "If you don't finish your vegetables, you won't get fruit")?[2]
Persuasive feeding	
PF1	Q47. If my child says "I'm not hungry" I try to get him/her to eat anyway.[1]
PF2	Q48. When your child refuses food they usually eat, do you insist your child eats it?[2]
PF3	Q49. I praise my child if (s)he eats what I give him/her[2]
PF4	Q50. Do you reason with the child to get him/her to eat (for example, "Milk is good for your health because it will make you strong)[2]
PF5	Q51. Do you tell the child to eat something on the plate (for example, "Eat your beans")?[2]
PF6	Q52. Do you say something to show your disapproval of the child for not eating?[2]
Covert restriction	

CR1	Q53. How often do you avoid going with your child to cafes or restaurants which sell unhealthy foods?[2]
CR2	Q54. How often do you avoid buying lollies and snacks e.g. potato chips and bringing them into the house?[2]
CR3	Q55. How often do you not buy foods that you would like because you do not want your children to have them?[2]
CR4	Q56. How often do you avoid buying biscuits and cakes and bringing them into the house?[2]
Overt restriction	
OR1	Q57. I have to be sure that my child does not eat too many sweet foods (lollies, ice-cream, cake or pastries).[1]
OR2	Q58. I have to be sure that my child does not eat too much of his/her favourite foods[1]
OR3	Q59. I intentionally keep some foods out of my child's reach.[1]
OR4	Q60. If I did not guide or regulate my child's eating, (s)he would eat too many junk foods.[1]
Structured meal setting	
SMS1	Q61. I allow my child to wander around during a meal.[2]
SMS2	Q62. I insist my child eats meals at the table[2]
SMS3	Q63. How often are you firm about where your child should eat?[2]
Structured meal timing	
SMT1	Q64. I let my child decide when (s)he would like to have her meal[2]
SMT2	Q65. I decide when it is time for my child to have a snack.[2]
SMT3	Q66. I decide the times when my child eats his/her meals.[2]
Family meal setting	
FMS2	Q67. My child eats the same meals as the rest of the family[2]
Use of TV/electronic devices Scale: **1.** Yes, No, Sometimes	
TV meals	Q68. Is the TV viewed by the family during meals
TV child	Q69. Are devices (phones, iPad, etc) use by children during meals
TV adult	Q70. Are devices (phones, iPad, etc) used by adults during meals
Frequency family meals (FFM)	
FFM	Q71. How many meals are eaten together as a family per week (Breakfast 0 – 7; Lunch 0 – 7; Dinner 0 - 7)
Depression, anxiety and stress scale (DASS-21)[373] Scale: 1. Never, Sometimes, Often, Always	
DASS S1	Q72. I found it hard to wind down
DASS A1	Q73. I was aware of dryness of my mouth
DASS D1	Q74. I couldn't seem to experience any positive feeling at all
DASS A2	Q75. I experienced breathing difficulty (e.g., excessively rapid breathing, breathlessness in the absence of physical exertion)
DASS D2	Q76. I found it difficult to work up the initiative to do things
DASS S2	Q77. I tended to over-react to situations
DASS A3	Q78. I experienced trembling (e.g., in the hands)
DASS S3	Q79. I felt that I was using a lot of nervous energy
DASS S4	Q80. I was worried about situations in which I might panic and make a fool of myself

DASS D3	Q81. I felt that I had nothing to look forward to
DASS S4	Q82. I found myself getting agitated
DASS S5	Q83. I found it difficult to relax
DASS D4	Q84. I felt down-hearted and blue
DASS S6	Q85. I was intolerant of anything that kept me from getting on with what I was doing
DASS A5	Q86. I felt I was close to panic
DASS D5	Q87. I was unable to become enthusiastic about anything
DASS D6	Q88. I felt I wasn't worth much as a person
DASS S7	Q89. I felt that I was rather touchy
DASS A6	Q90. I was aware of the action of my heart in the absence of physical exertion (e.g., sense of heart rate increase, heart missing a beat)
DASS A7	Q91. I felt scared without any good reason
DASS D7	Q92. I felt that life was meaningless
If you are experiencing anxiety, stress or depression, help is available from: Parent helpline: http://www.parentline.com.au/ BeyondBlue: https://www.beyondblue.org.au/	
Parent personal skills	
General nutrition knowledge	
Q93. According to the Australian Dietary Guidelines, 1/2 cup of cooked broccoli provides how many servings from the "vegetable" food group	0 serves 1 serve 2 serves 3 serves I don't know
Q94. Which of the following dairy foods do experts say children under 2 years should eat? (please pick one)	Full fat dairy Reduced fat dairy Mixture of full fat and reduced fat Neither, dairy should not be consumed under 2 Not sure
Q95. Which would be the best choice for a low fat, high fibre light meal for children? (choose one)	Ham and pineapple pizza Cheese on wholemeal toast Bake beans on wholemeal toast Quiche
Q96. Do you think these foods are high or low in salt? (Choose one option per food – high, low, not sure; food refer to 'original/standard' varieties)	Sausages Instant noodles Red Meat, e.g. steak Frozen vegetables Tomato sauce
Q97. Do you think these help prevent heart disease?	Eat more fibre Eat less saturated fat Eat less salt Eat more fruits and vegetables Eat less preservatives and additives

Beliefs and attitudes Scale: 1. Strongly disagree; Disagree; Agree; Strongly agree 2. Unimportant; somewhat unimportant, somewhat important, important	
Q98. Eating healthy is expensive[1]	
Q99. It takes too long to prepare a healthy meal[1]	
Q100. Healthy food doesn't taste good[1]	
Q101. How important is your family's nutrition to you?	
Q102. What resources do you usually use to update your nutrition knowledge? (please choose as many as apply)	internet/websites government material (e.g. Australian Dietary Guidelines); Magazines, newspapers, blogs; Nutrition textbooks or research journals; Radio or TV programs; Family Doctor; Child health nurse; Dietitian; Naturopath/ Fitness trainer; Family/ friends/kinship group; Other;
Kitchen/plate scape, home resources	
Scales 1. Strongly disagree, disagree, agree, strongly agree 2. Not usually, sometimes, mostly, always 3. I am mostly responsible; Another parent/adult is responsible; Both parents/ adults share responsibility; Other 4. Very poor; poor; good; very good	
103. The family home has suitable cooking facilities[1]	
104. The family home has suitable food storage (fridge, freezer, pantry)[1]	
105. The family home has enough money to buy food eat week[2]	
Q106. How often are fruits and vegetable available within the home?[2]	
Q107. Who is mostly responsible for the meal preparation within the home? [3]	
Q108. Who is mostly responsible for purchasing food for the family (e.g. grocery shopping)?[3]	
Q109. How many children live in the home? (continuous)	
Q110: How would you rate your shopping skills? (ability to purchase an appropriate amount and variety of food, ability to ready and interpret labels)[4]	
Q111. How would you rate your cooking skills (skills to prepare a meal from basic ingredients; skills and knowledge to use a variety of vegetables, confidence to experiment with unfamiliar ingredients)[4]	

Appendix 6: Parent reported severity, importance and motivation to address child feeding concern

Parent reported severity, importance and motivation to address child feeding concerns						
	5 **Extremely**	**4**	**3** **Neutral**	**2**	**1** **Not at all**	**Mean (SD)**
How serious are the consequences of [relevant child feeding] concerns?	2.1% (0.55-3.64)	26.4% (21.64 – 31.15)	34.8% (29.66 – 39.9)	30.6% (25.62- 35.57)	6.1% (3.51-8.68)	2.88 (.94)
How important is it to you that you get information and support to address [relevant child feeding] concerns?	14.8% (10.96 – 18.63)	50.9% (45.5 – 56.29)	24.2% (19.57 – 28.82)	8.2% (5.23 – 11.16)	1.8% (0.36-3.23)	3.69 (.89)
How motivated are you to make changes to improve [relevant child feeding] concerns?	20.9% (16.51 – 25.28)	61.5% (56.24 – 66.75)	15.8% (11.86 – 19.73)	1.2% (0.02- 2.37)	0.6% (-0.23 – 1.43)	4.01 (.69)

If you were to participate in a face-to-face program (participating 1 time per week), how long would you continue to participate for?	% (n)	95%CI
2 weeks	15.5% (51)	11.59 – 19.40
4 weeks	26.1% (86)	21.36 – 30.83
6 weeks	11.8% (39)	8.31 – 15.28
8 weeks	3.9% (13)	1.81 – 5.98
10 weeks	2.4% (8)	0.74 – 4.05
12 weeks	2.7% (9)	0.95 – 4.44
Longer than 12 weeks	6.7% (22)	4.00 – 9.39
Would not participate	30.9% (102)	25.91 – 35.88
If you were to participate in an online program (participating 1 time per week), how long would you continue to participate for?	% (n)	95%CI
2 weeks	7.6% (25)	4.74 – 10.45
4 weeks	12.7% (42)	9.10 – 16.29
6 weeks	11.2% (37)	7.79 – 14.60
8 weeks	8.8% (29)	5.74 – 11.85
10 weeks	2.4% (8)	0.74 – 4.05
12 weeks	9.4% (31)	6.25 – 12.54
Longer than 12 weeks	42.7% (141)	37.36 – 48.03
Would not participate	5.2% (17)	2.80 – 7.59
95% confidence intervals (CI) of sample mean assumed a 0.05 significance level and a two-sided alternative hypothesis		

Appendix 7: Ethics Approval Letter for Survey 1

THE UNIVERSITY OF QUEENSLAND

Institutional Human Research Ethics Approval

Project Title:	The Impact of the Family Food Environment in Shaping Eating Behaviours in Early Childhood (2.00 - 4.99 Years) and the Implications for Obesity Outcomes
Chief Investigator:	Ms Nikki Boswell
Supervisor:	Prof Peter Davies
Co-Investigator(s):	None
School(s):	School of Medicine
Approval Number:	2016000860
Granting Agency/Degree:	PhD
Duration:	31st July 2019

Comments/Conditions:

Expedited Review - Low Risk

Note: if this approval is for amendments to an already approved protocol for which a UQ Clinical Trials Protection/Insurance Form was originally submitted, then the researchers must directly notify the UQ Insurance Office of any changes to that Form and Participant Information Sheets & Consent Forms as a result of the amendments, before action.

Name of responsible Committee:
Behavioural & Social Sciences Ethical Review Committee
This project complies with the provisions contained in the *National Statement on Ethical Conduct in Human Research* and complies with the regulations governing experimentation on humans.

Name of Ethics Committee representative:
Associate Professor Elizabeth MacKinlay
Chairperson
Behavioural & Social Sciences Ethical Review Committee

Signature Liz MacKinlay Date 22/6/16.

Appendix 8: Ethics Approval Letter Survey 2

THE UNIVERSITY OF QUEENSLAND

Sub-Committee Human Research Ethics Approval

Project Title:	Study of acceptability for a novel online intervention design to support parents create healthful family food environments (cross-sectional survey)
Chief Investigator:	Ms Nikki Boswell
Supervisor:	Professor Peter Davies, Dr Rebecca Byrne
Co-Investigator(s):	None
School(s):	Child Health Research Centre, Faculty of Medicine, UQ
Approval Number:	2017001504
Granting Agency/Degree:	UQ Research Scholarship and Centre for Children's Health Research funding
Duration:	30th November, 2017

Comments/Conditions:

- HREA Form, 06/10/2017
- Project Description_PIS and Informed Consent, 06/10/2017
- The Family Food Survey Pilot, 01/11/2017
- The Family Food Survey Website, 06/10/2017

Note: If this approval is for amendments to an already approved protocol for which a UQ Clinical Trials Protection/Insurance Form was originally submitted, then the researchers must directly notify the UQ Insurance Office of any changes to that Form and Participant Information Sheets & Consent Forms as a result of the amendments, before action.

Name of responsible Sub-Committee:
University of Queensland Medicine, Low & Negligible Risk Ethics Sub-Committee

This project complies with the provisions contained in the *National Statement on Ethical Conduct in Human Research* and complies with the regulations governing experimentation on humans.

Name of Ethics Sub-Committee representative:
Associate Professor Diann Eley
Chairperson
University of Queensland Medicine, Low & Negligible Risk Ethics Sub-Committee

Signature Diann Eley   Date **07/11/2017**